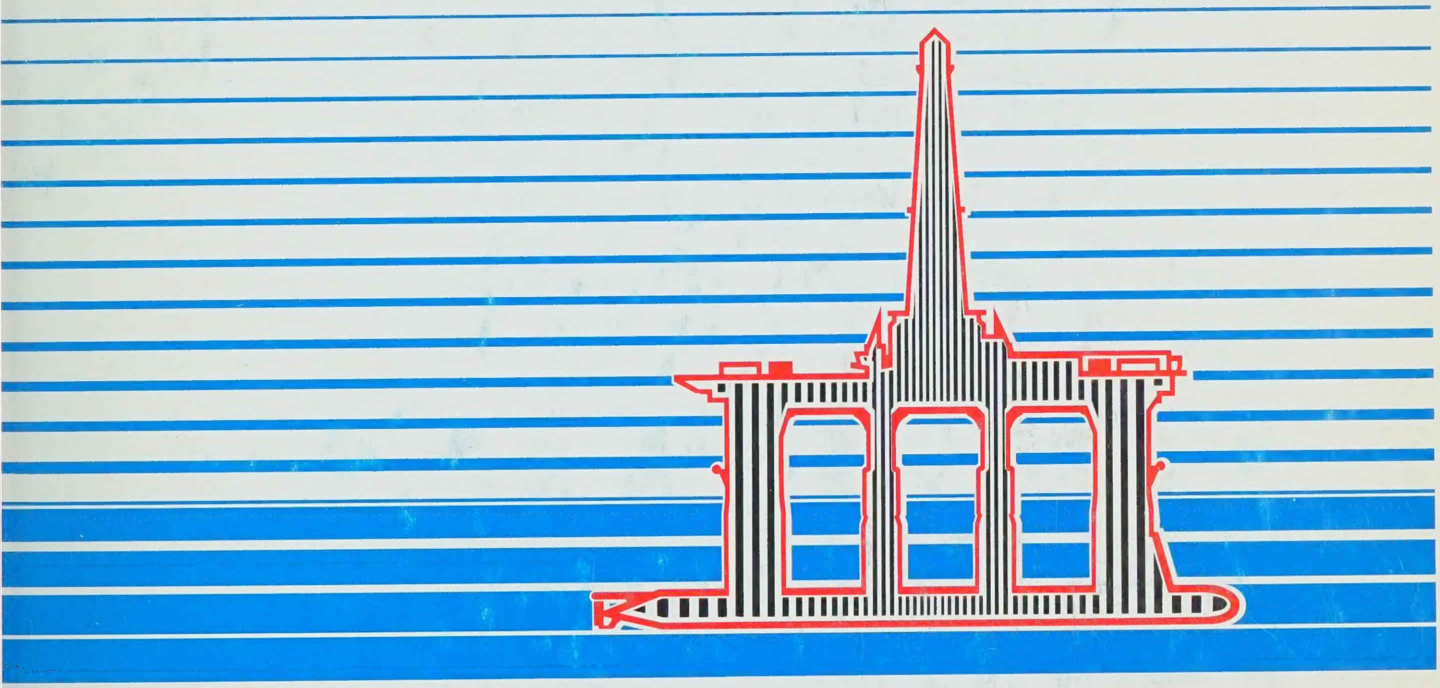
Royal Commission on the
cean Ranger Marine Disaster

Canada

Commission Royale sur le
Désastre Marin de l'*Ocean Ranger*

Newfoundland & Labrador



Report Two: Safety Offshore Eastern Canada

The Royal Commission on the *Ocean Ranger* Marine Disaster was jointly established and funded by the Governments of Canada and Newfoundland

Report Two: Safety Offshore Eastern Canada

Royal Commission on the *Ocean Ranger* Marine Disaster
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Commission Royale sur le Désastre Marin de l'*Ocean Ranger*
Newfoundland/Terre-Neuve

To Her Excellency
The Governor General

May It Please Your Excellency

We, the Commissioners appointed to inquire into and report upon the reasons and causes for the loss of all members of the crew of the semisubmersible self-propelled drill rig Ocean Ranger and of the Ocean Ranger on the 15th day of February, 1982 on the Continental Shelf off Newfoundland and Labrador and to inquire into, report upon and make recommendations with respect to safety offshore Eastern Canada, beg to submit to Your Excellency the following second report, which is our final report.

Chief Justice
The Honourable T. Alex Hickman
Chairman

The Honourable Gordon A. Winter, O.C.
Vice-Chairman

Fintan J. Aylward, Q.C.

Jan Furst, P. Eng.

M. O. Morgan, C. C.

N. Bruce Pardy, P. Eng.

June, 1985
St. John's, Newfoundland

Commissioners/Commissaires

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The Honourable Gordon A. Winter, O.C., Vice Chairman/Vice-Président
Fintan J. Aylward, Q.C.
Jan Furst, P. Eng.
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Counsel/Counseiller Juridique

Leonard A. Martin, Q.C.
David B. Orsborn

Commission Secretary/Secrétaire de la Commission

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The two reports of the Royal Commission on the *Ocean Ranger* Marine Disaster consist of the following four volumes:

Volume 1 **Report One: The Loss of the Semisubmersible Drill Rig *Ocean Ranger* and its Crew**

Volume 2 **Report Two: Safety Offshore Eastern Canada**

Volume 3 **Report Two: Safety Offshore Eastern Canada**
Summary of Studies & Seminars

Volume 4 **Report Two: Safety Offshore Eastern Canada**
Conference Proceedings, 1984

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Distilling the results of three years' work into this final report has been a formidable task. The staff of the Royal Commission has worked ably and imaginatively to reach its goal. Throughout the inquiry, the pressure of successive deadlines has called for long hours and a high degree of dedication. That we have completed our work within the forecast schedule is the result of their efforts and we thank them as individuals and as a group for what they have done. Their names appear in Appendix A, Item 1.

The Royal Commission has been fortunate in its external advisors who have made valuable contributions, some by preparing draft material to be used as a basis for sections of the report, others by providing advice and commentary at various stages of this inquiry. Their names are listed in Appendix A, Item 2. We are particularly indebted to our senior advisor, Dr. O.M. Solandt, C.C. and to the chairmen of the advisory committees on environment, design and construction, safety and training, and regulation, respectively: Dr. W.L. Ford, Dr. A.A. Bruneau, O.C., P.Eng., Dr. J.M. Ham, O.C., P.Eng., and Dr. A.E. Pallister. They helped us to mobilize and use productively the talents of a distinguished and knowledgeable group of people drawn from governments, industry and universities in Canada and abroad.

Throughout its work, the Royal Commission called on the governments of Canada and of Newfoundland and on the petroleum industry for a great deal of information relating to current offshore operations and to evolving policy and procedures. Dr. A.E. Collin and Mr. J. Fitzgerald for the two governments and Mr. K. Oakley for industry ensured that we received co-operation and they gave their personal support and encouragement throughout the process. The effective co-ordination provided by Mr. F. Brodie and Ms. S. Vorner-Kirby was in great measure responsible for the informed and prompt responses received from relevant federal government agencies and departments.

In addressing the second part of its mandate, the Royal Commission consulted widely and listened to the views of the many and diverse interests that are involved in this international industry. In completing its work, we acknowledge with gratitude the help and support we have received from innumerable people, some of them in government and in industry, others from among offshore workers and members of the general public. Their concern and the co-operation which have been manifested during the course of the inquiry need to be harnessed on a continuing basis in the interests of offshore safety.

The Honourable T. Alexander Hickman, Chief Justice

Commission Chairman

PREFACE

The capsize and sinking of the semisubmersible drilling unit *Ocean Ranger* on the Grand Banks of Newfoundland with the loss of its entire crew sent shock waves throughout Canada and beyond. The seriousness of the tragedy and its implications for future offshore drilling operations led to the establishment of Royal Commissions of Inquiry by both the Government of Canada and the Government of Newfoundland. In response to public concern that two official investigations would duplicate effort and create problems, the two levels of government moved quickly to combine the inquiries and adopt identical terms of reference. One Royal Commission was appointed jointly under the chairmanship of Chief Justice the Honourable T. Alexander Hickman, and the Chairman of the Provincial Royal Commission, the Honourable Gordon A. Winter, O.C., was appointed Vice-Chairman.

This unusual joint Royal Commission was given a unique mandate in two parts: the first and most immediate was to launch a formal inquiry into the loss of the *Ocean Ranger* and its crew; the second involved a process of study and consultation through which ways and means might be identified of improving the safety of eastern Canada offshore drilling operations.

In response to the first part of its mandate, intensive technical investigations were carried out and public hearings were held. These hearings began on October 25, 1982 and finished on March 22, 1984. On August 8, 1984 the Royal Commission submitted to the two governments *Report One: The Loss of the Semisubmersible Drill Rig* Ocean Ranger *and its Crew.* That report examined the reasons and causes for the loss and established the contributing factors. It analysed those areas of vulnerability within which lay the potential not only for the capsize of the *Ocean Ranger* but for other future disasters. This aspect is the basis for the transition from the specific concerns of the Part One investigation to the much broader approach that was adopted in the Part Two inquiry.

The Terms of Reference given to the Royal Commission for the second part of the inquiry (Appendix A, Item 3) called for it to:

> Inquire into, report upon and make recommendations with respect to both the marine and drilling aspects of practices and procedures in respect of offshore drilling operations on the Continental Shelf off Newfoundland and Labrador and . . . to the extent necessary and relevant, such practices and procedures in other eastern Canada offshore drilling operations.

It was recognized that these Terms of Reference would have to be brought into much sharper focus. It was decided to exclude the development and production aspects of offshore operations and to limit the subject of investigation to offshore exploration

and delineation. The enhancement of human safety was seen to be the main issue; property safety was considered only to the extent that it affected human safety. Environmental safety was not regarded as a central issue for the inquiry although, because of the expressed concern of fishermen and environmentalists, attention was given to the impact of exploratory drilling operations on fish, on sea birds and on marine mammals.

A plan was developed for a study program which would provide the Royal Commission with a concise but comprehensive review of current information and knowledge in the main areas of concern: environmental factors, design, human safety, and regulatory control. An informed group drawn from industry, government and universities critically reviewed the study plan and a number of recommendations were made with respect to the proposed content of the plan and the process to be followed during the Part Two inquiry.

As a result of these recommendations, advisory committees composed of knowledgeable people were set up in each of the four principal study areas to assist in defining the nature and scope of the studies to be undertaken. These studies were carried out under contract by experts in the various fields and have been regarded as input to the Royal Commission, but the views expressed and conclusions reached are those of the authors. These reports have all been subjected to a process of peer review. They are listed in Appendix A, Item 13 and summaries of some appear in Volume 3.

A problem faced by all inquiries is that the world does not stand still to be studied. The moment a study is complete, the conclusions and information in it begin to be dated and it becomes clear that there are areas that have not been covered adequately. As the Part Two study program progressed, it was recognized that the Royal Commission required additional information and informed views in a number of areas. This need was met by appointing advisors and by bringing together groups of experts, drawn from industry, the consulting community, government and universities, for a number of one-day seminars to make presentations and to debate the issues.

Another problem was the validation of the data collected and of the conclusions suggested in the course of the studies and the seminars. It was decided to bring together knowledgeable people in a forum that would be conducive to the frank exchange of ideas on the basic issues with which the Royal Commission would have to deal in its final report. The medium chosen was an international consultative conference, Safety Offshore Eastern Canada, organized in association with Memorial University of Newfoundland, to which were invited experts from a variety of backgrounds. The formal presentations were designed to stimulate fresh thinking and constructive debate on the basic issues. Summaries of most of the draft study reports were sent to all participants in advance of the conference in the form of briefing papers. Shortly before the conference, Report One was released to the public and those who took part in the conference had access to the results of all the work that the Royal Commission had completed up to that time.

A notice calling for written submissions was issued in September, 1983 and was followed up by letters to associations, companies and other organizations directly or indirectly involved in worldwide offshore drilling operations. A number of submissions were received (Appendix A, Item 7) which have provided useful input to the Part Two inquiry. A notice was also issued inviting the views of the public on matters relevant to the Part Two mandate of the Royal Commission to be presented at public hearings in Halifax, Nova Scotia and in St. John's, Newfoundland. In the event, the response did not warrant proceeding with a formal hearing in Halifax. The final public hearing was held in St. John's on November 5, 1984. The Royal Commission met informally in St. John's and in Halifax with a number of individuals and public interest groups. A Commissioner, accompanied by Commission staff, visited rigs oper-

ating off Newfoundland and Nova Scotia, participated in safety meetings and interviewed rig workers (Appendix A, Item 12). Shortly thereafter, a worker representative chosen by fellow workers from each of six rigs attended a meeting of the Royal Commission to discuss current practices affecting the safety of offshore drilling operations.

Throughout the course of the past three years, there have been innumerable meetings between Commissioners or Commission staff and industry representatives, government officials, members of the academic and consulting communities, and members of the work force in the offshore drilling and related service industries. These have taken place in Canada, the United States and Europe. They include discussions with a wide variety of people in the course of visits to mobile offshore drilling units, training institutions and emergency facilities serving offshore marine and drilling operations off Newfoundland and Nova Scotia and in the North Sea (Appendix A, Item 11).

The process of an inquiry is in itself productive of change regardless of the results. While a Royal Commission is in existence, its presence induces self-examination and improvement. It is this awareness that is required on a continuing basis to maintain the offshore safety regime. Much still remains to be done.

No commitment has yet been made to proceed with development and production of eastern Canadian offshore oil and gas resources. The mounting pace of activity, however, foreshadows the transition from exploration to production. Canadians from all parts of the country are now employed in all aspects of this industry and their numbers will increase. Canadian regulatory authorities and the industry itself bear the responsibility for their safety.

INTRODUCTION

The inquiry by the Royal Commission has addressed three basic questions:

Why did the *Ocean Ranger* capsize and sink?

Why was none of the crew saved?

How can other similar disasters be avoided?

Answers to the first two questions and an initial answer to the third were provided in Report One. This final report presents the results of the investigation into the third area, the goal of which was to identify ways and means of improving human safety during exploratory and delineation drilling operations off eastern Canada.

The offshore petroleum exploration industry embodies in its many components the rapid evolution of many industrial and engineering traditions. Structural engineering, naval architecture, materials fabrication, protection and control systems, instrumentation and testing, aviation and marine engineering are only some of the obvious areas in which this industry has challenged these traditions and continues to challenge current ideas and practices. The industry deploys and operates physical systems in locations, particularly off the East Coast of Canada, where the complexity and intensity of the environmental phenomena in which they must function safely are severe by any standard, not yet fully known and uncertain in their effects.

The general regulatory environment in which the industry functions offshore throughout the world is an intricate one. It includes elements of voluntary self-regulation that have evolved in the marine shipping industry over two hundred years and in the petroleum industry during this century. Other elements are embodied in international rules and agreements on marine safety, and in regulations imposed by the Flag and the Coastal States that draw on safety legislation founded on shore-based industrial traditions. This highly mobile international industry is increasingly subject to the requirements of many Coastal States and of international bodies committed to the formulation of codes and regulations that can be applied wherever the industry may operate.

In seeking to enhance the safety of offshore drilling operations in a practical way, it is recognized that human safety is a state of freedom from actual harm but not from risk, a state of being secure even when threatened. The more involved the activity, the more attention and the greater priority must be given to analysis, review and surveillance if human safety is to be maintained, let alone enhanced. The weakest links in any system, which are seldom the most obvious, must be identified and either protected or strengthened. The pace of change demands that standards be constantly reviewed and revised and that effective mechanisms exist to implement the

process speedily. The hazards to be encountered in offshore drilling need to be seen in the perspective of the risk that surrounds all human endeavours.

The loss of the *Ocean Ranger* and its crew was examined in Report One against the industrial-marine background, the emerging regulatory system and the evolving technology that are still characteristic of offshore drilling operations. In addition to inquiring into and reporting upon the reasons and causes for the loss of the rig and its crew, the Royal Commission was also required to report on a number of specific matters that were relevant to the accident. These included: some aspects of the design of the *Ocean Ranger* and of its critical systems; the command structure; the composition of the crew and how the rig was manned; operations on the Grand Banks leading up to the disaster; all aspects of safety of life at sea, including the sufficiency of available lifesaving equipment; and the regulatory system and how it functioned. Although none of these factors was found to have contributed directly to the disaster, all were deemed to have been instrumental in contributing, although often indirectly, to the loss of the rig and its crew.

This report now critically examines the same key aspects of offshore drilling operations and analyses those areas of continuing vulnerability in which may lie the seeds of future disasters. The introductory section includes a brief historical review of the international industry with an account of its activities and record off eastern Canada. This is followed by a chapter that provides a perspective on safety, considering its relationship with risk, costs, human nature and the compromises made in these relationships. The introductory section concludes with a chapter which assesses our knowledge of the physical environment in which eastern Canada offshore drilling operations are conducted. This environment – the waves and currents, the weather and the ice – affects the design of the structures and systems that are built to function there and also the day-to-day management decisions which determine the ongoing safety of the operation and of the people employed in it.

There follows a chapter on design, in which the roles of rig designers, builders, and owners of mobile offshore drilling units (MODUs) are analysed, as well as the roles of classification societies and regulators. The chapter also examines critically the process that is followed to design a MODU and to maintain the integrity and safety of its structure and of its key systems throughout the life of a rig. It also examines the mode of determining the suitability of MODUs for operations off eastern Canada.

The safety and seaworthiness of a MODU depend on its being properly designed, built and maintained to operate in the environment for which it was intended but they also depend upon its being properly managed and manned. The next chapter of the report provides a critical examination of management responsibility at the levels of the operator (the oil company holding the permit to drill), the owner of the MODU (the drilling contractor retained by the operator) and on board the MODU itself. Command structure, the process for reaching operating decisions affecting the safety of the rig, the management of safety in the workplace and the participation by workers in the process are all examined in this chapter.

A chapter follows on training, which analyses the level and quality of training for safety required of the crew of the drilling unit. It examines critically the requirement for orientation, specialist, team, and emergency training. The discussion of operations concludes with a chapter on occupational health and safety which analyses the basic issues affecting health care on offshore drilling units.

The section on emergencies opens with a chapter on escape from the MODU and on survival in the event of an unplanned evacuation. It contains an examination of existing means of evacuating a rig and of surviving in a harsh environment, while awaiting rescue. The chapter concludes with an analysis of possible improvements to lifesaving equipment and of how innovation in this field might be encouraged and supported.

A chapter on rescue provides an analysis of the capability of industry and of government to rescue workers engaged in eastern Canada offshore drilling operations in the event of an emergency and considers measures required to improve their capability and organization and to provide an acceptable level of rescue services.

The chapter on regulatory control considers the modes of control adopted by both government and industry for offshore drilling operations, and analyses the Canadian regulatory framework and practices in comparison with those of Norway, the United Kingdom and the United States.

The final section contains the conclusions and recommendations which are, as in Report One, presented in relation to the Terms of Reference of the Royal Commission. A brief epilogue chapter deals with the impact of offshore drilling operations on marine life. Appendices contained in this volume and the material in the accompanying volumes will be of assistance to readers who require supplementary information. They provide a synopsis of the data base, which supports the analyses and conclusions in Report Two. Summaries of the study reports, together with summaries of the organized seminars are included in Volume Three. Volume Four contains the proceedings of the international consultative conference on Safety Offshore Eastern Canada.

1

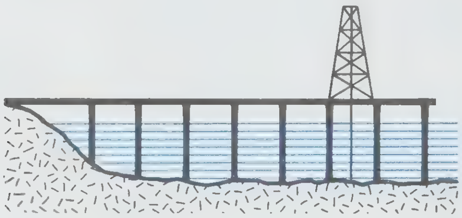
HISTORICAL REVIEW

CHAPTER ONE HISTORICAL REVIEW

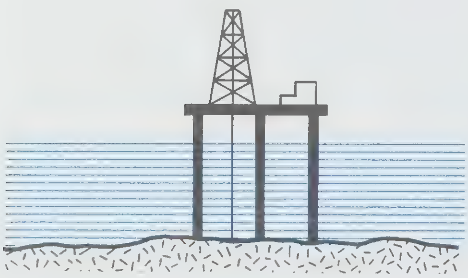
The petroleum industry as we know it today is often depicted as a monolithic, multinational giant affecting every aspect of the global economic system. Its operating base includes both industrial and consumer product manufacturing and distribution, but its raw materials come from the exploration and production of oil and gas reserves, both on land and over water. The industry began in the nineteenth century with the discovery of substantial hydrocarbon deposits, primarily in North America. The increased economic need for petroleum, coupled with easily accessible reserves, provided the industry's pioneers with the stimuli they required to locate and exploit petroleum resources and to develop increasingly efficient drilling technology. Around 1900, these same motives induced expansion into exploratory drilling over water, and by the early 1950s, offshore exploration and production had become an industry in its own right with its own experts, service companies, and equipment to cope with the unique problems of drilling at increasing water depths into the seabed.

The complex technology that is currently in use by the petroleum industry to find and develop offshore hydrocarbon resources has evolved over the past one hundred years. The first recorded offshore drilling venture took place in the late nineteenth century near Santa Barbara, California, where the presence of oil had long been recognized. In the 1860s, natural asphalt seepages were extracted from the beaches and prospectors eventually discovered that oil-bearing formations extended underneath the ocean. In 1897 the first "over-water" exploration wells were drilled from wooden stages which extended from the shoreline, and by 1900 beaches in the Summerland, California area displayed clusters of wharves, up to 1,200 feet in length, from which exploration wells were successfully drilled.

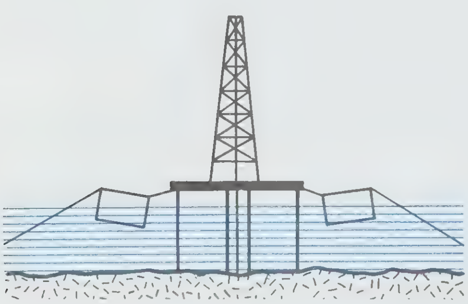
Oil and gas seepages, similar to those found on the California coastline, were prevalent in the Caddo Lake area of northeastern Texas and northwestern Louisiana, where in 1870 a well intended to locate water encountered natural gas. This accidental discovery caused numerous technical problems associated with well control. Blowouts were frequent in early gas wells and, in some instances, uncontrolled wells burned for years. As a result of the Caddo Lake experience, the United States government enacted well control regulations, and, through lease sales, limited the development of land surrounding and beneath the lake. To conduct drilling operations over water, equipment was transported by barge to the drill site where a drilling platform and pipe rack, like those used on land sites, were constructed. Wooden pilings were driven to provide a fixed base for the drilling equipment. In 1911, Gulf Oil Limited, using this type of drilling system, produced the first oil from underneath an inland lake. Platform design and production techniques pioneered by Gulf in Caddo Lake became an accepted standard in the industry and were used to produce oil in Lake Maracaibo, Venezuela, in the early 1920s. Derrick foundations progressed



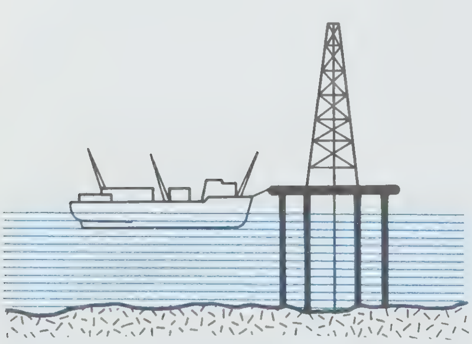
1.1 Offshore drilling rig evolution.
Wooden stages, 1897-1918
Water depths to 30 feet.



Pile-supported platforms, 1910-1940
Water depths to 60 feet.



Submersible barges, 1933-1960
Water depths to 20 feet.



Fixed platforms and tenders, 1934-1960
Water depths to 75 feet.

from wood to concrete, and by the 1930s, steel derricks became the standard.

Geophysical and seismic exploration along the coastlines of Texas and Louisiana produced numerous prospects, but the open bays, bayous, lakes and swamps of the area presented unique problems and required a totally different approach to platform design. Because of the silty subsoil of the Gulf Coast, Texaco Inc. commissioned the construction of a submersible barge equipped with a derrick and drilling equipment for exploration on inland waterways and lakes. The barge could be floated to a drilling site, flooded and submerged to rest on the bottom which provided a solid support for drilling. This innovative concept eliminated the costs of constructing fixed platforms because the barge could be refloated and moved to another site when drilling was completed. The first submersible rig, consisting of two barge hulls each with several watertight compartments, was designed to operate in ten feet of water. A distribution manifold with seacocks adjusted the flow of water during submerging. A steel superstructure supported the derrick, drilling machinery, pipe racks, and ancillary equipment such as mud tanks and pumps. Submersible barges provided an efficient and economical method for exploration of inland waterways.

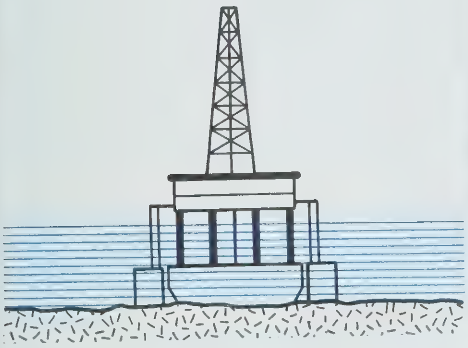
As exploration in the Gulf of Mexico expanded in the 1930s, it was still restricted to drilling from fixed platforms. In 1947, Kerr McGee Oil Industries pioneered an innovative platform design which was considerably smaller than those previously used in the Gulf of Mexico. The derrick and basic drilling machinery were located on a small fixed platform, with ancillary equipment, consumables and crew's quarters located on a floating tender. Since the platform and tender were stationed farther offshore, they had to be capable of withstanding increased wind and wave forces. This design proved quite effective but the mooring system was not always capable of keeping the tender on location during severe weather.

The oil industry responded favourably to Kerr McGee's innovative concept which subsequently inspired the design of floating structures for the entire drilling operation. In 1948, John Hayward designed a drilling platform combining the submersible barge and pile-support concepts. Hayward's design incorporated two pontoons which could be ballasted or deballasted independently. The barge hull could be floated to a drilling location, then submerged to rest on the bottom, providing the platform with the necessary support, freeboard and stability. By 1949, the industry's first mobile drilling platform was launched and operated on several locations in water depths of up to 18 feet. In 1954, the Ocean Drilling and Exploration Company (ODECO) built a submersible barge based on Hayward's concept to operate in water depths of up to 40 feet. Operators began to commission similar designs for deeper water, adding buoyant vertical columns at each corner of the platform.

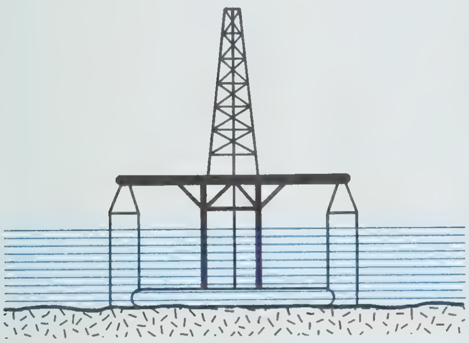
As activity in the Gulf of Mexico increased, other areas of the United States, principally the California Coast, became interested in exploratory drilling. Public pressures discouraged the use of fixed platforms there and the industry was forced to examine alternate designs. The result was an experimental program in 1953, which converted a navy vessel to a ship-based floating drilling system by installing a cantilevered drilling platform amidship. This experiment resulted in the development of equipment and systems which compensated for the vertical motion of the ship (heave) and its effect on the drilling operation.

In 1956, the first purpose-built drill ship was completed. The drilling platform and derrick were located amidship over a hole through the hull called the "moonpool". The vertical motion characteristics of the drill ship were substantially compensated for and, as more drill ships were designed, improvements to the industrial and marine systems evolved rapidly. A slipjoint to compensate for vessel motion was developed, improved mooring systems were designed, and a subsea system was devised to position the wellhead on the ocean floor. The design of the slipjoint and heave compensation systems permitted drilling to continue in moderate seas and enabled the operator to suspend operations during storms.

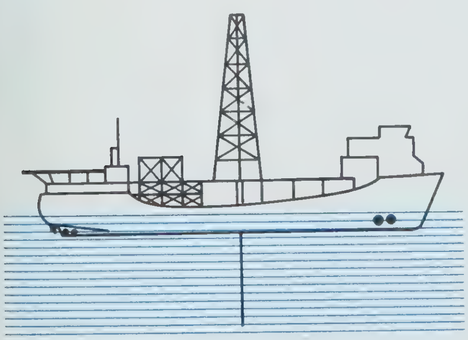
1.2 The *Mr. Charlie*, a submersible barge with hinged pontoons, built for the Ocean Drilling and Exploration Co. (ODECO) in 1954. Completely rebuilt in 1982, the rig is still in service in the Gulf of Mexico and is capable of drilling a 25,000-foot well in 40 feet of water.



Submersible barges, 1949-
Water depths to 45 feet.



Submersible barges with buoyant columns, 1956-
Water depths to 175 feet.



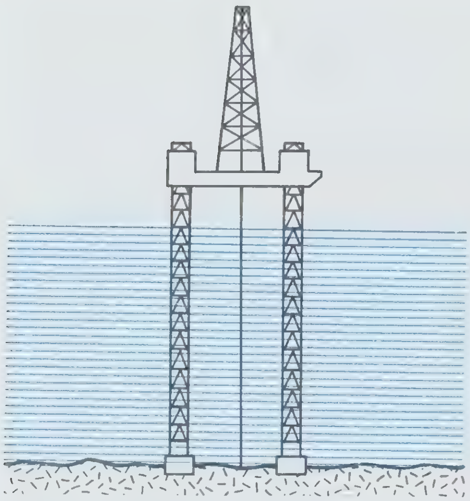
Drill ships, 1953-
Water depths to 6,000 feet.

The industry continued to design and improve drilling units that were stable, mobile and cost effective. Their research led to the evolution of truly mobile (self-propelled) floating drilling units and through the 1960s the drilling fleet expanded in size and type. Four generic forms of mobile drilling units evolved from the design innovations tested in the 1940s and 1950s. The submersibles and jack-ups were bottom supported and the drill ships and semisubmersibles were free-floating.

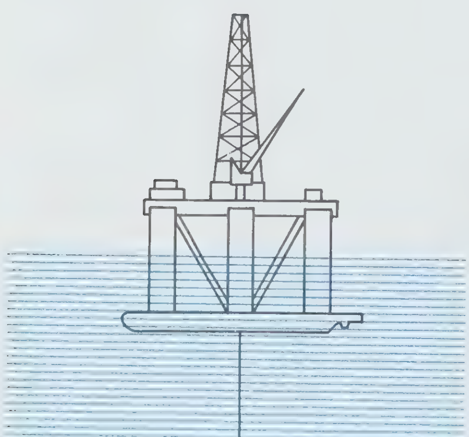
Submersibles generally have an upper hull for drilling equipment and crew's quarters, and a lower hull for flotation while in transit and for bottom support while in the drilling mode. The rig is usually towed to the drill site where its lower hulls are flooded until they rest on the sea floor. In this position, the submersible is a relatively stable drilling platform. Once the drilling is completed, ballast water is pumped out of the lower hulls and the submersible is refloated. Because the submersible is designed as a bottom-supported drilling unit, its operation is limited to water depths of up to 175 feet. With the increasing requirement for exploration in deeper waters, the submersible fleet has seen limited growth since the 1960s.

The "self-elevating" or jack-up rig is the most widely used platform in today's offshore drilling industry. The basic design first appeared in the 1950s. The jack-up has a large buoyant hull fitted with a number of retractable legs. The platform can be towed, transported on barge or self-propelled to a drill site with its legs drawn up above the deck. Once on location, the legs are lowered until they make contact with the seabed. The deck, supported by the legs resting on the sea floor, is then jacked up above the water until a sufficient air gap is created to permit drilling operations unhindered by wave action. While jack-ups provide a stable drilling platform on location, they are extremely unstable during towing and jacking operations and can be used only where the seabed provides a solid foundation for the legs. As with the submersible, the jack-up rig is restricted by water depth. Current designs can accommodate depths in the order of 400 feet. In Canada they are used at present only in relatively ice-free areas such as the Scotian Shelf.

The drill ship received more recognition after successful experimental programs in California in the late 1950s. The ship-shaped design permits a large cargo capacity requiring less frequent resupply. The benefits of self-propulsion allow drill ships to operate in deep water, with the assistance of either conventional mooring or



Jack-ups, 1953-
Water depths to 400 feet.



Semisubmersibles, 1962-
Water depths to 6,000 feet.

dynamic-positioning systems. Because of the hull shape, however, drill ships tend to have poor motion response, particularly in respect of heave. Since the efficiency of an offshore drilling program is affected by the motion of the drilling platform, drill ships tend to be restricted to regions having small wave heights and low wind velocities. In Canadian waters drill ships are used on a seasonal basis primarily in the Beaufort and Labrador Seas.

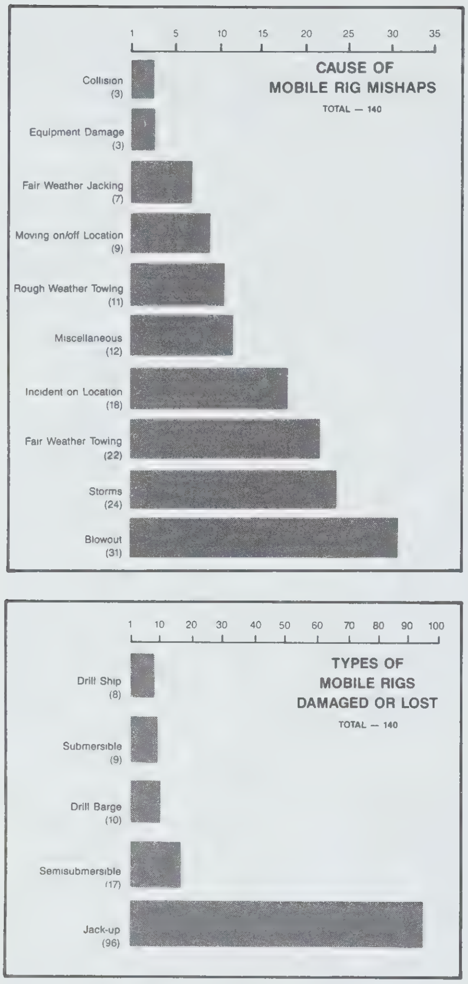
The semisubmersible evolved from the submersible drilling unit and was introduced in the early 1960s. It had been found that the submersible exhibited satisfactory stability characteristics during all stages of ballasting operations and, with certain structural changes, a submersible drilling unit could be designed to be partially submerged, providing a floating platform with good stability. As the industry began to explore deeper waters and harsher physical environments, the use of semisubmersibles became increasingly advantageous. The structural arrangement of the semisubmersible consists of a deck supported by a number of vertical columns, cross braces and pontoons which have sufficient buoyancy to float the entire structure. This arrangement makes the semisubmersible very stable and reduces the effects of wave action, since much of the vessel is below the surface of the sea while drilling. The pontoons of the semisubmersible are designed for storing bulk liquids, such as fuel oil and drill water, and salt water for ballast. When the semisubmersible moves from the transit mode into the drilling mode, it is ballasted down by taking sea water into its ballast tanks. During drilling the deckload changes continually as supplies are consumed and the rig takes on or pumps out ballast water to maintain its draft, trim and stability.

Since the introduction of the semisubmersible, a wide variety of designs has evolved. Many of the early units were designed to operate in both the free-floating and the bottom-supported condition and the drill floor and derrick were located at either the edge of, or overhanging, the deck structure. The *SEDCO 135* or "arrowhead" design is typical of the first generation of semisubmersibles. In the 1970s, designs began incorporating improvements resulting from earlier experience in the Gulf of Mexico and the North Sea. The deck structure was made rectangular and the drill floor was placed close to the centre of buoyancy; motion effects on the drilling operations were thus reduced. Improvements were also made in the mooring systems and several rigs were fitted with either partial or total dynamic-positioning systems. The semisubmersibles of the 1980s have more standardized structural designs which reduce construction costs. The basic principles, however, of stability, mobility and reduced motion characteristics, upon which the first generation of semisubmersibles was designed, still apply.

During the past two decades there has been a rapid acceleration in the evolution of offshore technology. The growth in demand for petroleum, the drive to achieve national self-sufficiency in energy, the apparent depletion of known land-based reserves, and the vagaries of OPEC policies have led to a surge of exploration on a worldwide scale into deeper waters offshore under increasingly harsh environmental conditions. The evolving new technology has made possible exploration off the East Coast of Canada, particularly with semisubmersibles. Exploration began there in 1960 when geophysical and seismic surveys were undertaken to locate potential hydrocarbon reserves. The first exploratory well on the Grand Banks was completed in 1966 and since then the pace of exploration has continued unabated. Major oil companies have conducted year-round exploratory drilling on the Grand Banks and on the Scotian Shelf as well as seasonal drilling programs in the Labrador Sea and the Gulf of St. Lawrence.

Discovery of oil on the Grand Banks in the Hibernia field was announced in 1979 and later oil was also found in the Hebron, Ben Nevis and Terra Nova fields. To date, all four discoveries indicate the potential of sufficient oil to support production. On the Scotian Shelf, gas in quantities estimated to be potentially sufficient to

1.3 The continental shelf off eastern Canada covers a vast area. Since the first well was spudded there in 1966, exploratory drilling activity has gradually increased; in May, 1985, a total of twelve MODUs were operating off Newfoundland and Nova Scotia.



1.4 Types of MODUs damaged or lost, and the cause of the incident, 1955 to 1981. A number of other rigs, including the semi-submersible *Ocean Ranger* and the drill ship *Glomar Java Sea*, have been lost since that time.

support production has been discovered in the Venture and Glenelg fields. Gas in significant quantities has also been discovered in the Labrador Sea but the possibility of production there is at present slight because of impediments to operating in this ice-frequented area. In the Gulf of St. Lawrence there has as yet been no significant discovery of either oil or gas.

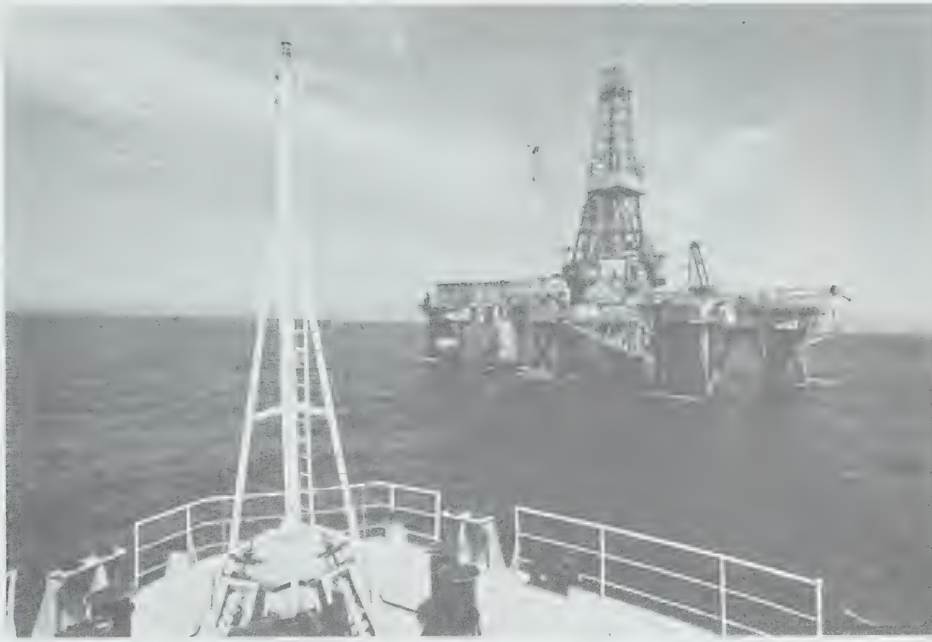
Offshore production on the eastern continental shelf is contingent upon sets of complex variables. The number of persons employed offshore will therefore be contingent upon the mode and pace of production and the extent of new discoveries. Several employment estimates for persons working on exploration rigs, production platforms and service vessels have been prepared but at present they are largely conjectural.[1] More precise estimates must await the preparation of offshore development plans. What is clear, however, is that when production begins there will be a significant increase in the number of persons who will be at risk working offshore, and safety will become an even more complicated problem because of the greater risks inherent in the production process.

In the search for and production of oil and gas in deeper water and harsher climates, the industry has had to face many risks and problems that constantly test the bounds of known technology. But the oil industry has a strong tradition of tackling difficult engineering problems and solving them successfully. It has accordingly brought this approach and the practical experience on which it was based to the evolution of offshore drilling techniques. The objective has remained unchanged: to provide a stable platform from which to drill. It is not surprising, therefore, that the pursuit of this central purpose has been by the extrapolation of existing land-based oilfield technology and the extension of tested methods.

Despite this predominantly industrial focus the activity takes place at sea. The unique nature of this industrial-marine endeavour, together with the constant evolution of new technology, has presented a challenge to agencies established to set standards and to govern the design and activities of more traditional craft. These agencies have tended to evolve their standards and their role, as did the rig designers, on the basis of experience. It was not until 1968 that a classification society developed rudimentary rules to govern the design and construction of MODUs and only in the 1970s did governments begin the process of developing regulations to control the activities which were occurring off their coastlines. Consequently, as the industrial technology evolved and accidents occurred, so did the regulatory system develop. The Caddo Lake blowout of the 1930s provided the stimulus for improved well control regulation. The loss of the *Sea Gem* in the 1960s focused concern on the structural integrity of MODUs and led to the development of classification rules which addressed the specific requirements of this type of floating structure. Latterly, the loss of the *Alexander L. Kielland*, the *Ocean Ranger*, and the *Glomar Java Sea* centred concern, on the part of both industry and government, on the adequacy of existing design and construction methods, training requirements, evacuation systems and rescue capabilities.

Past experience clearly indicates that the causes of accidents which result in either the partial or total loss of MODUs, and endanger the lives of the personnel who work on them, include environmental factors such as wind and waves, the design, construction and operation of the MODU itself, and the capability of those on board to deal with emergencies. There is generally no single cause of these accidents, as experience, particularly in the case of the *Ocean Ranger*, has shown. Blowouts have led to over 22 percent of all mishaps on MODUs and represent the largest single contributing factor to major offshore incidents. Structural fatigue, towing incidents, collisions, stability losses, drilling equipment malfunctions, fires, and explosion are also major factors which have led to partial or total MODU losses.

[1] These estimates fall in a range between 4,000 and 7,000 people. There are currently around 3,000 people working within the eastern Canada offshore.



1.5 A semisubmersible drilling on the Grand Banks of Newfoundland. Although drill ships were used there in the earlier years of exploration activity, the semisubmersible is now widely employed because it provides a more stable platform; jack-ups have not yet been used on the Grand Banks, primarily because of the presence of pack ice and icebergs.

The safety record shows that some types of MODUs are more prone to mishaps than others. The self-elevating or jack-up type has been the most vulnerable to damage or total loss; almost 70 percent of all mishaps since 1955 have occurred with jack-ups. There are unique characteristics of the jack-up which account for the higher incidence of mishaps: when its legs are jacked up for transit, its centre of gravity is high and consequently so, too, is the risk of capsize; during the jacking process there is the risk of punching through the seabed and losing stability. Drill ships and semisubmersibles have also had their share of mishaps since blowouts and structural failures are as applicable to these MODU types as they are to jack-ups. Most of the accidents to floating MODUs, however, have resulted from loss of stability because of mechanical failures, collisions, structural failures or human error.

Analysis of the risks in exploratory drilling off Canada's East Coast is limited by lack of experience. Although exploration began there in 1960, the total experience in terms of rig-years has been approximately 50 compared with 5,000 worldwide. No significant statistical conclusions about safety performance of drilling operations offshore eastern Canada can consequently be drawn. It has however been demonstrated that blowouts can occur as in the case of the semisubmersible *Vinland* and the jack-up *Zapata Scotian*. In both cases moderate wind and sea-state conditions made evacuation of the crew possible without loss of life. In the case of the *Ocean Ranger*, a chain of events including faulty design, a winter storm and lack of knowledgeable intervention led to the loss of the rig and of all on board. There have also been less serious accidents resulting from collisions with supply vessels and near-accidents from passing ships and icebergs.

Accidents may occur to support vessels, to helicopters, and to divers as well as to rigs. The seismic vessel, the *Arctic Explorer* sank in July 1981, with the loss of 13 crew members and the supply vessel, the *Seaforth Jarl* sank in 1984 when its cargo shifted during a winter storm because it was improperly secured. Accidents to helicopters used to transport crew and supplies have occurred in the North Sea. There have been recent helicopter accidents off eastern Canada and experience elsewhere indicates that this risk will increase and that more precautions will be required as exploration and production activities expand. Although diving activities off eastern Canada have not been accident-free, the safety record is appreciably better than in the North Sea or the Gulf of Mexico.

With the advent of the modern offshore drilling industry, the increasing complexity of the industry's organizational arrangements has fostered a dilution and diffusion of responsibility and of accountability of all the participants – designers, builders, owners, operators, contractors, and regulators. The *Ocean Ranger* disaster highlighted many of the deficiencies in the total management process which underlies and controls an offshore exploration operation. These deficiences have raised concerns in the minds of the public at large about the industry's ability to conquer the Northwest Atlantic and government's ability to assure acceptable standards of safety for persons working offshore and for those who will work there during the development and production phase. It is to these concerns that this Report is addressed.

2

PERSPECTIVE ON SAFETY

CHAPTER TWO PERSPECTIVE ON SAFETY

The *Ocean Ranger* marine disaster was not an isolated event. Its loss, following so closely upon the capsize of the *Alexander L. Kielland* for a combined loss of 207 lives, has raised serious questions regarding the reliability of the technology involved in drilling operations under winter conditions in the Northwest Atlantic and regarding the adequacy of the measures being taken to ensure the safety of those engaged in these operations. It has also raised questions regarding the nature of the risks that should be undertaken in the pursuit of oil and gas offshore.

Offshore drilling is predominantly an industrial activity taking place in a marine environment rather than a marine activity undertaken for industrial purposes. It is an extension to the oceans of a land-based industry where injuries to personnel at work are not uncommon and where catastrophic events such as blowouts and fires have punctuated the history of operations.

Those who live by the sea and earn their living from it have learned through experience how dangerous the sea at times can be and how cautious one must constantly be in facing the perils of the deep. The risks inherent to drilling into the earth's crust, when combined with these perils, make offshore exploration and drilling an unusually hazardous activity in which the achievement of acceptable levels of safety demands reliable technology, capable management, competent workers, and unrelenting vigilance.

The offshore oil industry is, of necessity, on the cutting edge of technological innovation. Until recent years, technology has been almost entirely the result of an evolutionary process extending back over several centuries. In this process, the traditional approach to safety has been: first, to identify and examine carefully all potential hazards; second, to do everything possible to eliminate the hazards or to mitigate their consequences; and finally, to proceed cautiously according to established principles. Whenever this evolutionary process has been ignored and a quantum leap forward taken, tragedy tends to result, as in the case of the collapse of the Tacoma suspension bridge when an innovative design, exceeding proven proportions, failed to take into account vitally important aerodynamic considerations. Man has learned from experience to do more of the right things and fewer of the wrong and to know that sound engineering principles, proven over time, are ignored at his peril.

Man's use of technology to extract mineral resources from the earth, to generate and distribute energy, to harvest timber and crops, to manufacture goods, to erect buildings, to transport and distribute people, messages and goods, has generated wealth but also created risks to life and limb. In spite of the contribution of technology to human welfare, people today are questioning, on a scale never before witnessed, the direction and values of western society and are expressing concern regarding the resulting threats to human safety from acid rain, toxic contaminants in

2.1 The devastating results of a blowout on a fixed production platform. Although well control technology continues to advance, the potential for the violent release of hydrocarbons from subsea wells is always present.

food and water, nuclear power, and a seemingly endless list of other putative hazards. Yet it is out of technology-based activities that the wealth is created to sustain health care and other social services that improve our collective welfare. There are those who would demand an assurance of complete safety before new ideas or new technology could be applied. If that had been the guiding rule in the evolution of the human race, man today would be a simple competitor with other predators in a hunting society. The great majority, on the contrary, have, often tacitly and without facing the underlying issues, opted for a cautious advance into the unknown. An underlying dilemma, however, is that those who reap the benefits may not be the same persons whose safety is endangered.

But, what is safety? The term in its human context has no meaning except in relation to potential risk of harm. It is essentially a relative term, the complement of risk. Risk is not new to our times and place. It has been a pervasive and persistent factor of man's condition since the beginning of life. It remains a constant companion, since man is daily at risk whether at home, at work, or on the highway. It is a feature of everyday life nor can it be avoided. There is no such thing as absolute safety; all that is achievable is a state or condition that can be deemed to be "safe enough" – acceptable to society and capable of being tolerated by those directly involved.

Human perception of risk varies whether the perception is individual or public, whether the risk is voluntary or imposed. The perception also varies with time, with place, and with the context of the activity. Man individually takes risks voluntarily and routinely that would cause a collective uproar, if imposed to the same degree by a corporate or public body. We are loath to have others do unto us what we consciously do unto ourselves. Perception of risk is highly coloured by the culture of a society and the context within that culture in which the activity takes place. Risks accepted as normal in some cultures would not be tolerated in others. The risks faced by a roustabout on an oil rig or a sailor on a ship are peculiarly different from those of an office worker on land. The risks encountered by those who earn their living on the sea or by steelriggers on high-rise structures may appear highly dangerous and recklessly undertaken to a prairie farmer. Perceptions change over time, and risks of years ago would not be acceptable to society today.

Many factors influence our perception of risk. One of the most potent of them is fear of the unknown – of the future side effects of current scientific enterprises and of new technologies; of radiation, for example, undetected by any of the senses, the effects of which may be long delayed even to the next generation. Another factor is the size of the disaster, real or apprehended. The crash of a large aircraft, the loss of

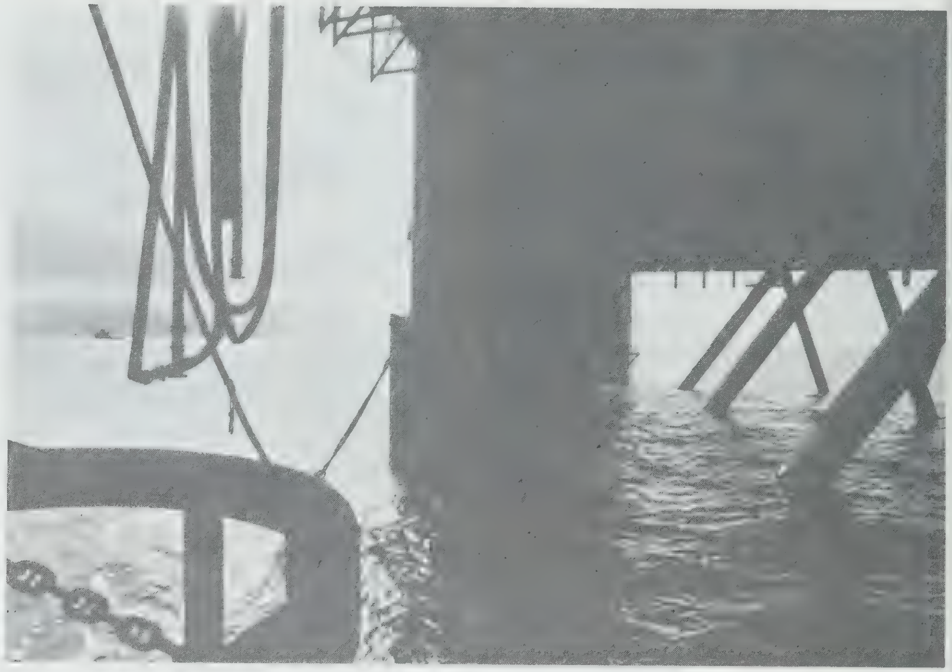
a semisubmersible, the collision of a school bus at a railroad crossing cause shock and an outcry for improved safety measures. And yet, hundreds more people are killed in automobile accidents and die unnoticed except for those close to them. It is also a curious feature of human nature that a society which balks at heavy expenditures to prevent possible accidents and which permits, for example, a lack of protective covering over a well will spend unlimited sums to rescue a child who has fallen into one.

The incidents that nowadays attract public attention arise in complex systems of men and machines. A classic example of a complex system is an offshore drilling operation. It has a unique feature, adding to the normal risks to be faced, in that it combines marine and industrial cultures in a hazardous marine environment, thus creating demanding challenges both for the designers of rigs and for their operators. In the operation of offshore drilling rigs, as of all complicated structures, the essential element in safety, however good the technology involved, is the human element. The maintenance of the quality of the drilling rig as a safe haven and as a productive platform depends critically upon sound practices in operating those systems, such as ballast control and well control, through which human intervention to avert an emergency can take place. The standards to which safe practices are carried out depend on the clarity of organizational authority and its delegation, on the judgments of supervisors, on the competence and experience of specialized teams and on the native abilities, training and morale of all workers. Significant weakness in any dimension of the human element will reduce the working margin of safety and may, as in the loss of the *Ocean Ranger*, contribute directly to a chain of events that ends in catastrophe. For real safety in any technology is a highly human factor and a heavy price is exacted for carelessness, ignorance, or poor judgment on the part of those involved.

The failure of any critical system is of singular concern because these systems provide the means for exercising human control of the drilling rig during normal operations and in emergencies. In complex technologies, such as aerospace, nuclear power and chemical processing, it is customary to protect against failure in critical systems by having backup or redundant means of control, and to instrument the operations so that the fact of failure is made transparently evident to those responsible for intervening. While the offshore oil industry has appropriated the latest technology in seismic exploration, drilling and the structural design of drilling units, it is by no means clear that it has done so to an equivalent level in the instrumentation and redundant control of critical systems. Neither has the industry stimulated the responsible governmental regulators to give leadership in ensuring that more reliable and technically feasible means of escape and survival in emergencies are devised and required.

The rig designer must design a drilling rig that is stable, efficient and seaworthy under all prescribed and foreseeable circumstances. There is no doubt that perfect safety is unattainable in an imperfect world. In the real world, some measure of safety must be surrendered, some degree of risk must be accepted, if an economical and useful drilling unit is to be designed and constructed. What that measure or degree is at any period of time is determined by prevailing economic and social evaluations. If it is deemed to be too high, the activity will not be undertaken. In the actual practice of striking the balance between cost, utility and safety, the key factors are engineering judgment based upon knowledge, experience, and proven technology, and the accountability of those making the decisions.

The overall failure of technological systems to sustain the safety of those who operate them stems from three primary causes: from external environmental disturbances, internal failures of basic structures or critical subsystems, and ill-conceived human action or lack of knowledgeable intervention in response to evidence, real or apparent, of abnormal behaviour. Human competence is at the core of safety in the use of technologies. In the face of external disturbances such as a collision with a



2.2 The Grand Banks present an ever-changing environment in which offshore drilling equipment must function efficiently and safely. When transformed by high winds and seas, such as those encountered on the night of the loss of the *Ocean Ranger*, the Northwest Atlantic challenges even the most recently designed drilling rigs.

supply vessel that punctures a compartment of a pontoon, or of internal failure of air supply to a well control system, competent human intervention may often recover a large part of any potential loss in the margin of overall safety. There is dramatic historical evidence that, as in the loss of the *Ocean Ranger*, incompetent human intervention can destroy margins of safety.

In the operation of a drilling rig, as in all industrial endeavours, safety ultimately depends upon the individual who has been carefully selected and trained for the task that he or she is expected to perform. Individuals have the responsibility of being alert to ensure their own safety and that of others who by their acts of omission or commission may be put at risk. To this end, everyone must know his or her job thoroughly, be physically and mentally fit to perform all assigned tasks even under emergency conditions, and have the intelligence and education, particularly if the position involved is a key one, to know when something goes wrong and what action then to take. Training to the level of knowledgeable intervention, when it is required, is the key to the safety of the individual and of others. The operation of any intricate system of man and machine requires teamwork and the conscious recognition by all members of their responsibility for their own safety and for the safety of the other members of the team. Their safety may be endangered if too many ill-trained or inexperienced persons are inserted into the team at any one time.

There are those who seek reduction of risks through increased regulation. During the past few decades, there has been a great increase in regulatory control without comparable discernible benefit. Regulations do not of themselves ensure safety and may be counterproductive in their consequences. Responsibility for safety may become a complacent acceptance of rules and regulations, and the evolving technology that is applied may be only as good as the rule and the rule formulators. Those who argue for greater regulatory control ignore the ever-present human element. The human element in safety in this context has two basic dimensions. It is expressed in the judgments that determine the characteristics of the equipment and of the personnel coming together to constitute a MODU operating at a particular time and place. Designers, builders, owners, operators and regulators working as part of an evolving industry all influence this outcome. Second, the human element is expressed in the quality of the judgments made in resolving the balance between safety and

2.3 The remote and demanding work environment of an offshore drilling rig requires a commitment to safety by all those involved. The knowledge, judgment and trained responses of the driller form the first line of defence against well control problems.

productivity during operations. These judgments are guided by a fabric of safe practices carried out by the personnel on board. Thus, here too, safety depends fundamentally on human integrity, judgment and competence. Regulation can establish performance standards in critical areas of technology and operating practices but it cannot encompass the many dimensions of human behaviour that contribute to or detract from safety.

Many are involved, upon whom those who work on the rig must depend for their safety – those who may never be identified but whose engineering knowledge and sound judgment are brought to bear in the configuration, detailed design, and construction of a rig capable of meeting performance standards under anticipated environmental conditions. They are the naval architects, metallurgists, steelmakers, welders, and a host of others. They are the designers who create the structural system and who devise specialized subsystems, such as for ballast control, communications, and evacuation. Then there are the inspectors who exercise control during the construction process. All share responsibility and in some way should be held accountable.

A mode of enhancing safety that is likely to be more effective than regulations is a more rigorous enforcement of this principle of accountability; the continuing professional responsibility of those involved in the design and construction of the drilling rig, and their accountability for its structural integrity and for the efficacy of its systems; and the overriding responsibility of the drilling contractor who owns and operates the rig and of the operator who has the permit to drill, both of whom must be held accountable for the safety of the rig and of its crew. There is a risk involved in practically every human activity, and no precautions at any price can make any activity completely safe. The accepted practice in business is to seek a compromise where the level of expenditure on safety reduces risk to a tolerable level, while maintaining potential benefits sufficiently high to make the venture economically attractive. In pursuit of this goal, the decisions in the design and construction process leading to an acceptable compromise are numerous and complex and are made by many professionals, but the chief executive officer of the company owning the rig must accept responsibility and be held accountable for the wisdom of these compromises.

High standards of safety in the workplace are achieved when well-designed equipment is operated properly by well-managed and well-trained persons. Occupational safety is maintained by keeping these factors in a state of positive balance, in what is normally a highly dynamic situation. It requires constant vigilance to ensure that equipment is kept operating within permissible limits, that the persons responsible for each aspect of the operation continue to be well selected for the tasks they do, and that they are knowledgeable about what they are doing. The more demanding the work and the work environment, the more essential it is to ensure that a continuing effort is made to maintain their health, their motivation, their safety consciousness and, thus, their commitment to safety.

When man attempts new ventures in a harsh environment, unforeseen events are bound to occur in spite of the most careful preparation. Harmful effects from these unforeseen events can be kept to a minimum by ensuring that safety is borne in mind throughout the entire process of planning, construction, and operation. The level of safety that is achieved in any rapidly evolving industry depends, more than anything else, on the commitment of the senior management of rig owners and operators. Therein lies the path to greater safety.

3

ENVIRONMENTAL FACTORS

CHAPTER THREE ENVIRONMENTAL FACTORS

Man and the sea are age-old adversaries; man covets the riches of the oceans but the oceans are jealous guardians of their wealth. For centuries the Northwest Atlantic has been harvested for its live bounty; now man seeks a newer treasure – hydrocarbons – the fossilized remains of the ocean's ancient life. Those who lead this uncharted venture are equipped with the most sophisticated means yet devised to combat the forces of wind and wave. But they have had to learn the lessons of our seafaring past: the sea cannot be conquered; it must be endured.

Those who prospect for oil and gas are faced with quandaries unknown to earlier men of the sea. Fisherfolk traditionally build the sturdiest craft within their means to launch upon the ocean. That these vessels may not be sturdy enough is known to all; such is the tariff exacted by the sea from those who would harvest its waters. Today's technology promises something more, something safer. The huge drilling rigs come close to achieving this goal; the effects of the ocean's swell are restrained; the elements shut out by a carapace of steel, and the sheer mass of the structure offers its tenants a land-like security. But even these hybrids of marine and industrial technology may not be sturdy enough. One must wonder how a technology that protects man as he ventures to the moon and back cannot protect him from his ancient enemy, the sea. The answer lies not in logic, but in the more modern science of economics. Drilling rigs could indeed be fabricated to resist any environmental force known to man; but so to construct them would render the venture that they are designed to service economically unfeasible. Thus the sea continues to claim its toll in lives, and those who seek to diminish that toll recognize that any progress that they make will merely be relative to the higher costs that might have been.

The offshore oil industry, like other modern enterprises, counters the risk to its work force by promising protection. If there is any likelihood of a drilling rig failing an environmental test, activities cease and man withdraws to the land. As sea ice and icebergs invade the exploration areas off the East Coast of Canada each year, rigs and fishing boats alike retreat to safer quarters. As hurricanes are forecast to sweep through the Gulf of Mexico or typhoons through the China Sea, crews are evacuated and those rigs that cannot be moved are left to the mercy of the storm. These strategies involve high costs in lost drilling time. Yet the total figure is much lower than the cost of providing drilling fleets that are so designed and so constructed that they will survive the harshest extremes that the environment can muster. From the perspective of industry, then, present withdrawal and evacuation procedures form a responsible compromise between the often conflicting ideals of human safety and economic feasibility.

That this compromise works reasonably well is evidenced by the statistics. Although many MODU accidents have been attributed to environmental factors,

relatively few of them have resulted in lost lives; threatening conditions were generally forecast well enough in advance to enable the crew to be brought to safety. There are two key criteria which control the success or failure of this strategy. First, industry must know with precision what environmental conditions are to be anticipated at a given drilling location. Only then can rigs be designed to surmount these forces and environmental limitations be established for the evacuation of the rig. Second, forecasting procedures must be so developed that accurate and timely warning is afforded of those approaching extremes which may warrant precautionary action. These key criteria are accommodated to varying degrees in different offshore regions of the world. Some areas of exploitation, like the North Sea, have been subjected to years of careful environmental mapping and the data needed for the analysis and estimation of normal and extreme conditions are relatively well documented and readily available. The East Coast of Canada is a more isolated area that is new to offshore activity; there, data are comparatively sparse and not always reliable. It is relatively simple to forecast dramatic departures from normally placid climatic conditions, for example a hurricane in the Gulf of Mexico; it is virtually impossible to predict accurately the path or velocity of an isolated iceberg in the erratic currents of the Northwest Atlantic.

Few areas in the world represent as challenging a drilling terrain as the continental shelf off eastern Canada. Nowhere else are permutations and combinations of wind, waves, fog, and ice as perilous and as unpredictable as in that vast and varied expanse of ocean. Environmental extremes on the Grand Banks generally include wave heights of 30 metres, winds of 100 knots, currents of 2 metres per second, frequent sea ice and icebergs, and heavy fog which limits visibility to below 1 kilometre as much as 45 percent of the time. These conditions influence both the design of exploration equipment destined for use in the area and the daily operations of the drilling rigs, supply vessels and helicopters that work at the drilling sites.

Industry's strategy of protecting the offshore work force by vigilant forecasting and timely evacuation faces a number of caveats off the East Coast of Canada. Some environmental factors in this region are imperfectly understood, and some predictive techniques inadequately proven. Even if rigs are designed such that they successfully resist the direct onslaught of sea and wind, the very frequency of adverse weather poses a myriad of problems. High winds and seas and heavy icing loads leave little room for error in the performance of men and equipment. A minor miscalculation or oversight in design, construction or operation which would prove inconsequential under normal circumstances, may be forced into the open to form the initial link in a chain of events that culminates in disaster. Such a chain was forged the night the *Ocean Ranger* was lost; although the storm did not sink the rig, it would not have sunk without the storm.

Should an offshore catastrophe occur, for any reason and in any location, environmental conditions will often determine how many lives are saved or lost. The eastern Canadian offshore again poses special problems. Even when warning is given of approaching ice or of a severe storm, helicopters may be unable to reach those on board a drilling rig because of fog, high winds, or icing, and a MODU may be unable to move off location if seas are too rough to permit anchor-handling or towing. Should the emergency be precipitated by a blowout or collision, there would rarely be enough lead time for helicopters to cover the considerable distance from shore. In each of these events, the only avenue of escape would be into the ocean. Estimates of the chances of a successful evacuation by sea with existing lifesaving equipment decline from 82 percent in calm weather, to 10 percent in severe weather.[1] With the frequency of severe conditions off the coast of Newfoundland and the dire

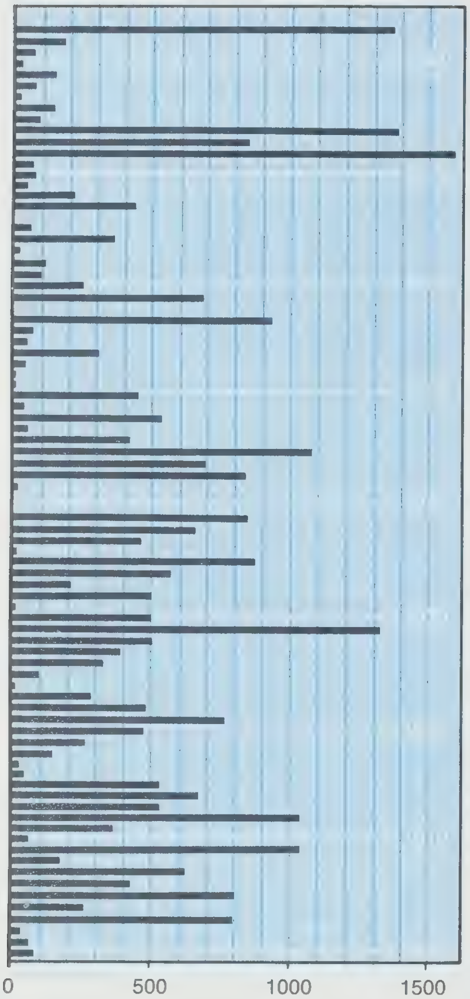
[1]A joint study project by the U.K. Department of Energy and the U.K. Offshore Operators Association. Calm weather is defined as up to Force 3 and severe weather, Force 8 and above.

3.1 Collisions with ice still pose a threat to conventional ships in spite of the availability of radar and ice reports.

precedent of the *Ocean Ranger's* evacuation, this aspect of the environmental problem may well prove the most intractable and potentially the most tragic.

Those concerned for the protection of workers off Canada's eastern shores have raised questions regarding present levels of environmental information and existing methods of hazard prediction. The lessons of the *Ocean Ranger* disaster, the widely recognized inadequacy of contemporary evacuation systems, and the prospect of new problems as activity expands all warn against accepting a complacent assurance that all is well. As is man's way, it takes a tragedy of catastrophic proportions to effect significant change in society's methods of protecting its members. The loss of the supposedly unsinkable *Titanic* to an iceberg, not far from where drilling operations are now in progress on the Grand Banks, proved conclusively that icebergs were, indeed, a threat in the Northwest Atlantic shipping lanes and that lifesaving equipment was, indeed, inadequate. It is hoped that other environmental threats in this harsh milieu need not exert the same burden of proof before man admits that they, too, pose a problem, and that the designation "unsinkable" remains a relative and largely utopian term.

Neither those who design and build MODUs for the eastern Canadian offshore nor those who operate and maintain them can perform their functions effectively without access to a diverse array of environmental data (Appendix C, Item 5). Information on ice, waves and wind are fundamental requisites; so too are data on how these complex elements interact and the extremes that they may attain. For centuries man has perceived a need for structures that would permit him to travel freely on the sea's surface and harvest its depths despite the presence of ice. Never has that need been more strongly in evidence than in recent years off the East Coast of Canada. Offshore operations may proceed or halt for weeks or months in response to the changing movements of pack ice and icebergs.



3.2 The yearly variation in the number of icebergs which complete the journey from the glaciers of Greenland to cross latitude 48°N. In recent years, the development of synthetic aperture radar and side-looking airborne radar has radically improved the effectiveness of ice reconnaissance programs. In 1984, the International Ice Patròl made 78 flights and 49 percent of the icebergs detected were attributed to the use of airborne radar. During that year 2,202 icebergs were estimated to have crossed 48°N.

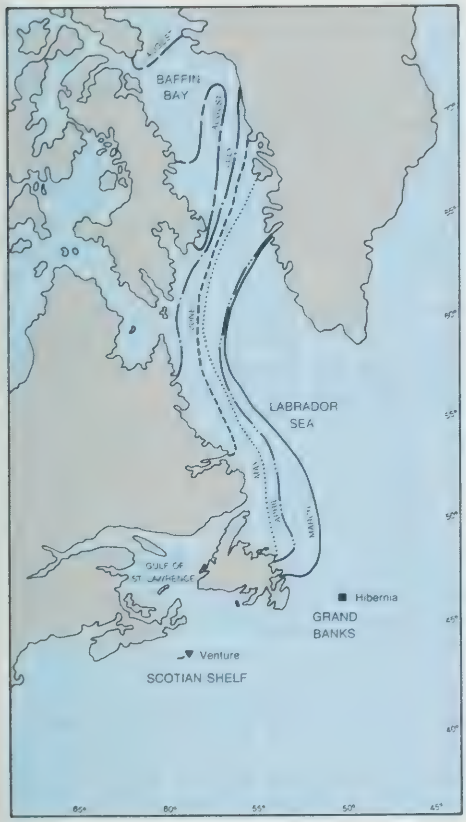
Pack ice or sea ice is formed by the freezing of the sea's surface layer and is found year round in the northern areas of Baffin Bay and Lancaster Sound. Although first-year ice rarely grows to more than two metres in thickness through the process of freezing, considerably thicker floes are built up by the continuous relative motion of wind and currents which generates both rafting and ridging. Rafting results when one ice sheet overrides another, and ridging forms when a line of broken ice is forced up or down because of pressure, and the blocks become frozen together. These processes produce the characteristic rough and ridged topography of sea ice.

As this ice ages, the brine is leached out and the ice becomes stronger. During the winter the Arctic pack expands and drifts southward until by late winter or early spring it reaches its maximum coverage, extending to the Grand Banks off the coast of Newfoundland. As this rugged, sometimes multi-year ice moves south, it breaks and scatters through packs of newer and locally formed ice. The sea ice that hovers north of the drill sites off Labrador in the fall and extends into the Hibernia area in the winter usually consists of Labrador ice interspersed with isolated Arctic floes and remnants of icebergs. Sea ice also forms in the Gulf of St. Lawrence, but this ice is not as thick as the Labrador pack and includes neither Arctic ice nor icebergs. In most years this pack extends over the northern Scotian Shelf but it has not yet been reported as far south as Sable Island.

Movement of pack ice off the East Coast of Newfoundland varies with winds and tides, but it can be surprisingly rapid, particularly when driven by the Labrador current. Reports of pack ice velocities averaged over a week have reached 40 kilometres per day at Hibernia and have exceeded 50 kilometres per day in the Avalon Channel. Pack ice moving at this rate can sweep a vessel along in its path and force a drilling rig off location. Since no drilling rigs and very few supply vessels operating in this area are Ice Class, these hazards, coupled with the danger of puncture by pieces of tough, Arctic ice, dictate the prudent practice of ceasing activity as sea ice encroaches.

Another sea-borne hazard in the Northwest Atlantic is the iceberg, the mariner's legendary foe. Calved from the glaciers of Greenland, these leviathans of the north may weigh many millions of tonnes. Their journey south is a slow progression subject to the vagaries of wind and current and the undulations of the sea floor. Relatively few icebergs escape the confines of the fiords where they were born, and even fewer survive the one- to three-year journey to the warmer, lower latitudes. Although the southern limits of their sightings, the Grand Banks of Newfoundland, have known ice-free seasons, in other years over 2,000 icebergs have moved south of 48° north latitude.

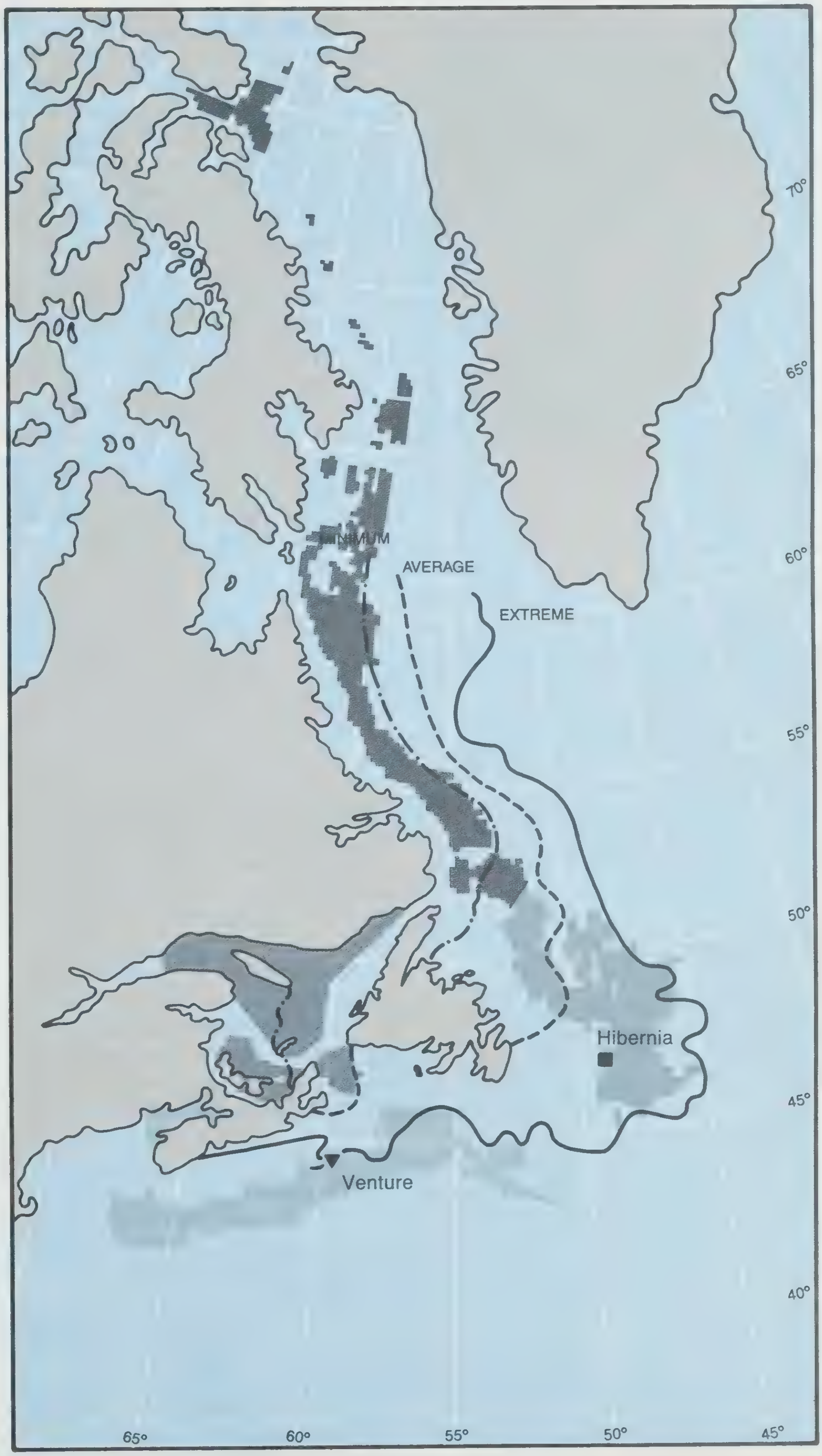
Iceberg ice is harder than sea ice, partly because it derives from fresh water and partly because of the way it was formed. As E.J. Pratt described the iceberg in *The Titanic*, "pressure and glacial time had stratified / The berg to the consistency of flint." This hardness has long made the iceberg the most formidable environmental force in these waters. Large icebergs can generally be avoided; it is the smaller progeny that worsen the already complex operating conditions in eastern Canadian waters. As the iceberg journeys south, warming by sun and sea produces fractures which split the berg into fragments called "bergy bits" and "growlers". These offspring can be approximately but conveniently classified according to above-water dimensions and total mass. A bergy bit will look as large as a typical small house and weigh up to 7,000 tonnes; its smaller sibling, the growler, appears above water the size of a grand piano and will usually be under 200 tonnes in weight. When we are dealing with vistas as broad as the isolated drilling sites of the Northwest Atlantic and structures as massive as oil rigs, there are few environmental enemies to be feared as much as the diminutive, undetected growler, camouflaged amidst floes of softer sea ice, or borne at speed in storm-lashed waves, to crash with deadly impact against any obstacle in its path.

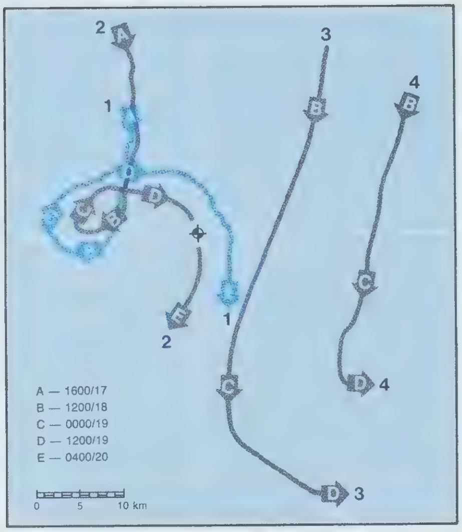


3.3 Pack ice, composed of Arctic ice and locally formed sea ice, poses particular problems for drilling operations on the Grand Banks. In the spring of 1985 pack ice and icebergs, driven by strong winds and the Labrador current, completely covered the Hibernia drilling area and resulted in the cessation of drilling for almost eight weeks.

Approximate drilling season:

- 3 months
- 3 to 5 months
- 8 months
- 8 to 12 months
- 12 months





3.4 The paths of four icebergs near a wellsite off the coast of Labrador illustrate the difficulties encountered in predicting iceberg trajectories. Although iceberg movement is predicted twelve hours in advance, an examination of 1,000 individual predictions revealed that about 70 percent of the forecasting errors exceeded four nautical miles.

Those exploring for oil and gas off the East Coast of Canada have addressed the challenge of icebergs by developing a system of "ice management" which is predicated on avoiding collision with ice. This approach is used in the ice-frequented waters off Labrador where dynamically positioned drill ships are employed for seasonal exploration. The strategy has been adapted for use further south in the Hibernia field where semisubmersible drilling rigs are used year-round. Because anchored MODUs take considerably longer to move off position than those dynamically positioned, it is essential that any ice in the vicinity of operations be detected and tracked at an early stage.

Industry's ice management program is built around a series of concentric alert zones which define the time it would take for the ice to reach the rig, and a corresponding series of actions or responses. The first recourse, if an iceberg is observed to be drifting towards a rig is to tow the berg. Accomplishing this feat in rough seas and high winds without the tow line slipping or the berg rolling over is always arduous and often impossible. Troublesome, too, is the herculean task of raising a rig's anchors if this first recourse fails and the rig is left with no option but to depart the drill site. Heavy seas and high winds make anchor-handling hazardous particularly if circumstances dictate that it be done quickly. The final resort, if environmental conditions are severe enough that anchors cannot be pulled and the iceberg is still approaching the rig, is to activate the quick-release mooring system which severs the anchor chains.

If an iceberg should escape detection and penetrate the inner alert zones surrounding a rig, if environmental conditions or time should preclude towing or anchor handling, if a mechanical problem should prevent the release of even one of the rig's eight to twelve anchor chains, then contingency plans can do no more; the fate of the rig is determined by the inexorable course of the iceberg. The likelihood of this series of events occurring is small but far from negligible. The likelihood of its occurring in weather conditions that prevent evacuation of the crew by helicopter or supply vessel is smaller yet, but, as history will testify, it is sufficient to invite serious reflection. In February of 1983, for example, the *West Venture* was drilling on the Hibernia field when storm conditions and approaching icebergs forced suspension of drilling. Helicopters could not fly because of freezing rain and poor visibility; anchors could not be pulled nor personnel transferred to supply vessels because of sixty-foot seas and eighty-knot winds. The quick-release mooring system had never been tested operationally and to activate it in storm conditions was judged less prudent than riding out the two-and-a-half day storm at anchor. Even had the anchor chains been released successfully, the rig was neither self-propelled nor capable of being taken under tow in the high seas, and would thus have drifted without control amidst the ice until the storm abated. Luck was with the *West Venture*; of the ten small icebergs and bergy bits in the immediate vicinity of the rig, none came closer than seven nautical miles. A considerably closer encounter with an iceberg was experienced by the *Bow Drill III* on the Grand Banks in April of 1985; unable to pull its last remaining anchor, or to severe the chain, the rig remained near the wellsite as the iceberg passed within one-half nautical mile.

Initially, each operator conducted his own ice management program, but in 1983, as a result of the *West Venture* incident, a joint industry and government surveillance group was formed for the Hibernia area to pool resources, data and detection capability. A common operations centre co-ordinates information received from regular reconnaissance flights by government and industry aircraft, from ice observers on board each drilling rig, and from the International Ice Patrol. The degree of coverage provided by this observing network is thorough but not infallible. Icebergs are poor radar targets; they can often be seen with the naked eye before they show on conventional marine radar screens. The possibility exists that a growler or bergy bit may slip through the surveillance net, particularly at night, or when visibility is

restricted by fog or heavy weather. Rough seas create "sea clutter" or interference on radar screens, masking the return from weak radar targets like growlers. By sea state 6, clutter extends far enough to reduce detection reliability for small targets to near zero. Research is underway to upgrade the capabilities for ice detection of both conventional ships' radar and sophisticated airborne-imaging radars.

When an iceberg approaches a drilling site, those in command are faced with a crucial task. They must determine whether the berg is on a collision course with the rig and, if so, whether it can be towed off that course by the supply vessels. This seemingly straightforward decision is charged with complexities. Methods in use today for predicting the path of icebergs cannot estimate berg movement beyond 12 hours' lead time and, even at this range, are not always dependable. This poor performance derives in large measure from the difficulties involved in estimating the direction and speed of the currents governing the berg's flow. These currents can be highly variable, even within a short distance, so much so that the net effect of the dominant current, its tidal component and the local wind can influence icebergs no more than five kilometres apart so that they travel in opposite directions. Measurements of the currents used for predicting an iceberg's course are generally taken at the site of the rig and not near the berg itself, a procedure which significantly affects the accuracy of the prediction. Advanced predictive models have been developed based on the previous trajectory of the iceberg; these show a slightly better performance record than the conventionally used methods. Other research is in progress to evaluate the feasibility of a model which measures the current within two kilometres of the actual iceberg by means of recently available acoustic current profilers.

In order to continue to operate safely among sea ice and icebergs, those involved in offshore exploration need to understand more clearly ice properties, ice behaviour and the chances and consequences of collision. Authorities at the National Research Council of Canada and the Norwegian Hydrodynamic Laboratories have specified their needs for new environmental data if they are to model the interactions between ice and man-made structures (Appendix C, Item 2). Much of this missing data involves measurements of the mechanical properties of sea ice and icebergs, including such parameters as strain rates and fracture resistance. This information will take years to accumulate and to apply in modelling, design and construction. There is also a need for more research and development in ice detection and in the prediction of iceberg movement. These tasks must be started now, if improvements are to be made in the efficiency and safety of drilling operations off the East Coast of Canada.

Icing is yet another environmental foe in northern climes. As super-cooled water droplets from sea spray, precipitation or fog strike frigid surfaces, the moisture freezes and forms an often impenetrable coating of ice. Icing is a common phenomenon off the East Coast of Canada as sub-zero winds blow sea spray from the tops of waves. The offshore supply vessels commonly used in this area are designed to carry a heavy icing load without losing stability, but many a conventional vessel has foundered or capsized under the weight of ice accumulated on its superstructure.

Drilling rigs are less vulnerable to sea spray icing than are conventional vessels; rigs tower above the waves and, as they are stationary, they generate no spray of their own. Although very few cases of serious rig icing have been reported in the eastern Canadian offshore, there is adequate evidence to warrant concern. In 1970 the drill rig *Sedneth* operating on the Scotian Shelf accumulated an estimated 200 tonnes of icing. At one stage the rate of ice loading increased the rig's draft by one foot per hour, bringing it close to its maximum allowable draft and preparations were made to dump drilling mud and cargo to compensate for the ice load when the accumulation ceased. Another example of severe icing occurred in Cook Inlet, Alaska; measurements on the semisubmersible *Ocean Bounty* were carried out in conditions that are environmentally possible over eastern Canadian waters. During this

3.5 Severe icing due to sea spray and freezing rain is a common phenomenon for vessels operating on the Grand Banks. Although icing may be less intense on drilling rigs due to their configuration and operation, there is no scientific basis upon which the probability of occurrence of extreme icing can be based. Several semisubmersibles constructed recently for operations in Arctic waters have incorporated deicing systems to prevent the accumulation of ice.

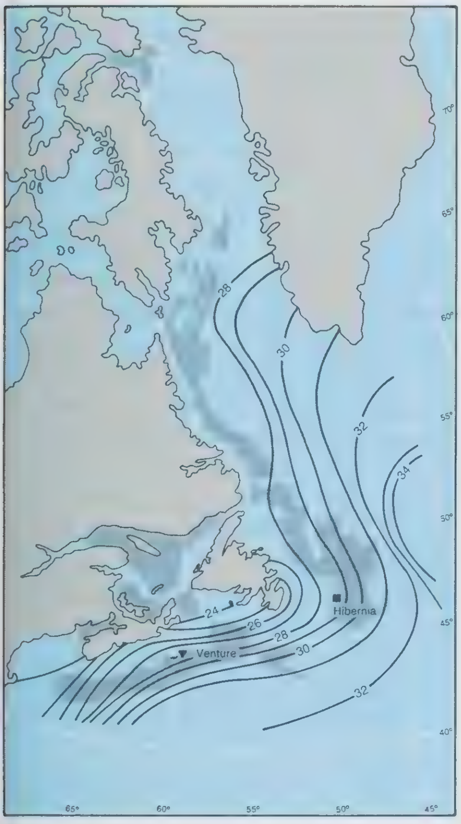
experiment, ice accumulation rates of from 5 to 25 centimetres per day were recorded, some in a zone as high as 30 metres above the sea surface. The total ice accumulation during a particularly severe period was estimated at 500 tonnes, enough to threaten the stability of the rig.

A more prevalent threat posed by icing is the danger to emergency equipment. Winches and release gear for lifeboats are affected by even moderate ice conditions and severe icing can make them inoperable. Helicopter operations are also susceptible to icing that is generated by mist-like particles of water in fog or cloud. This "rime" icing may restrict air intake or reduce lift by accumulating on rotor blades. Reports of rime icing frequently prevent or delay flights or force pilots to change altitude en route. During emergencies, these restrictions could prevent the timely arrival of rescue.

Current technological tools do not include the data needed to estimate reliably the likelihood of serious icing events offshore, to calculate accurately accumulation rates on fixed surfaces, particularly on the undersides of drilling rigs, or to develop vertical profiles of icing rates over water. These uncertainties pose problems for the rig designer and for operational safety offshore. Research into the physics and climatology of icing phenomena should be a priority for the meteorological community and the industry, and more accurate and useful methods of measuring and recording icing data should be sought.

Many a seaman who has known a North Atlantic storm would cite the sea's own turbulence as its most destructive force. Waves, those "broad Atlantic combers", have wrought havoc on scores of vessels and claimed hundreds of lives. An errant wave broke a portlight in the column of the *Ocean Ranger*, and the consistent lateral force exerted by waves weakened a crossbrace of the *Alexander L. Kielland*. High waves can interfere with offshore operations by preventing diving manoeuvres and impeding the transfer of cargo to or from supply vessels. Extreme waves can force a drilling unit to disconnect for fear of damage to equipment, and swamp a lifeboat or life raft.

Those who study wave climate use historical data to describe waves in statistical terms, defining, for example, the frequency of occurrence of various wave heights and periods and variations among these values seasonally and from place to place.



3.6 The 100-year wave contour for the East Coast offshore, based on analyses by the Canadian Forces Meteorological and Oceanographic Centre (METOC).

Reliable estimates of the extreme wave height, of the period and of the crest height are of prime importance for offshore safety and among the key data required by designers and classification societies. Another area of widespread interest is the distribution of the kinetic energy of waves as a function of time and wave frequency. This factor becomes important in estimates of structural fatigue and as a basis for simulating sea states in modelling tanks.

The wave climate off eastern Canada has been studied in three ways: by using the technique of hindcasting, by employing visual observations and by measuring waves directly with instruments. Hindcasting is a procedure for deducing from archived weather data for a particular area the corresponding sea states of that area. Wind speed, direction, duration and fetch are derived from records of the atmospheric pressure field. These data are then used to calculate the height, the period and the direction of the waves which would have been produced. If 20 to 30 years of relevant meteorological data were available, it would be possible to generate a statistically sound description of the wave climate for deep water. For offshore eastern Canada there is only one hindcasting model which is considered acceptable but its coverage is limited to the vicinity of the Hibernia field. Other hindcasts are not dependable because they model the coastline incorrectly, ignore the presence of pack ice or cover too few years of data to be statistically reliable.

Many ships at sea participate in a worldwide program of reporting meteorological conditions; these data include visual observations of wave height, period and direction. In Canada, the wave data received through this program are used by the Canadian Forces Meteorological and Oceanographic Centre (METOC) to produce wave charts for the Northwest Atlantic. This information is prepared every 12 hours and is then broadcast as part of the marine forecast. As this program began in 1970 it provides a record long enough for useful statistical treatment and is the basis of a detailed analysis of wave climate for the eastern Canadian offshore.

For wave data measured instrumentally, buoys are deployed to measure the movement of the water directly as the wave passes. There are, however, limitations in the usefulness of data supplied by these instruments. Wave direction is not recorded, buoys may under-record large waves, the steepness of the wave front is distorted, and the area coverage is limited because it is impractical to deploy the buoys in sufficient numbers to be representative of a large area. Despite these limitations, data records of appropriate length obtained from these instruments are indispensable for many design functions and as a spot check on other methods of describing wave climate.

The two studies that can be directly compared are the Hibernia hindcast and the METOC analyses. They give respectively values of 30 metres and 28 metres for the 100-year wave, that is the height of the largest wave expected to occur in 100 years, and 15.1 metres and 15.6 metres for the 100-year significant wave height, that is the mean height of the highest one-third of the waves measured. This degree of agreement may be fortuitous. The uncertainty assigned to the hindcast is ± 10 percent. The reliability of the METOC estimates may be lower than this as they are based upon visual estimates made by individual observers. Thirty metres is the height of the 100-year design wave which has been used by the industry as a criterion in the selection and operation of rigs for Hibernia.

The wave climate of a large area such as offshore eastern Canada will vary significantly with location. The design wave estimated for the Hibernia area does not represent the entire region in which operations may be carried out. Wave regimes become more severe as the distance from shore increases. Figure 3.6 shows the contours of the 100-year maximum wave as derived in the METOC analysis. On the line from the Avalon Peninsula eastward past Hibernia, the gradient is about $+1.8$ metres per 100 nautical miles. The significance of this gradient is that the design wave for year-round operations eastward of Hibernia may need to be increased. On the Flemish Cap or the Tail of the Banks, the indicated increase is about 3 metres or

10 percent over the Hibernia figure of 30 metres. Because of the uncertainties underlying these numbers, it would be wise to have the wave hindcast and the METOC studies extended and refined to increase the geographical coverage and to improve the confidence limits on design wave values.

One gap in the scope of present measurements, which creates problems for hindcasting, is the lack of simultaneous wind, wave and current measurements. These elements interact in a complex manner which is not fully understood. A reliable series of simultaneous data would help establish the relationship between wind, waves and currents in particular areas and allow designers and classification societies to develop hindcasts of current extremes, a process which is not now possible. These data would also have important implications for sea-state forecasting.

Wave studies to date have not incorporated the effects of shoaling bottom or of currents on wave properties. In water shallow enough for bottom effects to play a major role, as around Sable Island, this situation creates serious data deficiencies. Much remains to be learned about the physics of complex wave trains as they move into shallow water, often under the added effect of strong currents, before a reliable description can be provided of this special case of wave climate and its extremes. Scientists in Germany, Holland and the United Kingdom have recently reported some success in modelling wave generation and propagation in shallow North Sea waters. This work is indicative of the growing attention being given to the subject as it affects not only design criteria, but also such operational considerations as diving, siting of jack-up rigs, and station-keeping. There is an evident need for ongoing, longer term research to resolve this scientifically difficult problem as it applies offshore eastern Canada.

There are, then, a number of specific areas affecting offshore design and operations where more information and research relating to wave climate are needed. These areas include improving the methodology of estimating extreme waves, strengthening the research effort on the prediction of the wave regime in shallow water, and conducting definitive investigations on the interactions between wind, sea state and currents. It is also important to ensure the long-term continuity of instrumented wave recording at selected sites in order to provide essential calibration points for predictive wave climate models, and wave spectra for use in the analysis of structural fatigue in rigs and other design applications. Finally, improvements in wave recording, including wave direction, would increase the reliability and utility of wave data.

The wind, both friend and foe of the mariner, has normally little direct effect on the safety of offshore operations, other than helicopter flights. Of greater significance are its secondary effects in generating waves, currents and sea spray and in moving icebergs. Study is needed to define the nature of these interactions and also to resolve a number of problems relating to the measurement of winds for offshore applications: the vertical profile of wind in the marine atmosphere, particularly at anemometer height, which in the case of rigs can be up to 80 metres above the sea; the effects of structures such as rigs on the wind field; and the optimum averaging time for wind measurements at sea. Estimations of extreme winds also need refining, and firm figures for 100-year design winds should be developed for different areas of Canada's Continental Shelf.

In addition to the winds sweeping over the ocean, the ice covering its surface and the waves and currents churning its depths, the seabed itself has a bearing on the safety of certain offshore operations. Jack-up drilling rigs, anchors and subsea equipment all make direct contact with the ocean floor. The most critical interaction is with jack-up rigs which depend completely on the seabed for their support and which are susceptible to a variety of foundation problems. The most serious of these as it affects the stability of the rig is punch-through, a situation which generally occurs when the rig is jacking up on location, and one leg penetrates a supposedly solid foot-

ing area to drop into a soft layer of soil below, plunging rapidly until solid resistance is encountered at some lower level.

Because of the threat to both equipment and human lives represented by punch-through, accurate knowledge of the bearing capacity of the seabed is a necessary prerequisite to siting jack-up rigs. Seabed information is available for most of the eastern Canadian offshore in the form of maps showing the distribution of various types of sediments and rock outcrop. Maps alone, however, are insufficient for selecting an actual drilling site, and for identifying potential punch-through conditions. The usual practice is to conduct a detailed site-specific survey which includes geophysical as well as soil testing and bottom sampling techniques. In some cases, sampling to some depth into sediments by borehole drilling is necessary to define foundation conditions.

At the present time the use of boreholes is discretionary in surveys for siting jack-ups. Existing statutory regulations applicable to the eastern Canadian offshore do not specifically require geotechnical investigations at drill sites although guidelines describe the geophysical and geotechnical information which may be appropriate and require that a report be submitted and signed by a professional geophysicist or geologist. There are those in the industry and the scientific community who feel that borehole sampling should be mandatory for the selection of jack-up rig sites and their arguments are convincing. A draft guideline requiring borehole sampling has recently been issued by the Canada Oil and Gas Lands Administration (COGLA) for comments from the operators.

In light of the many environmental hazards that confront those exploring for oil and gas off Canada's eastern shores, there can be little question about the importance of accurate forecasting. Precise foreknowledge of the timing, intensity, rate of increment, duration and path of storms, high winds, fog, or icing conditions all represent vital input into daily operations, contingency planning and emergency procedures. The scale of predictions required ranges from the very broad to the very narrow; long-term forecasts influence the planning for seasonal drilling programs, reliable 48-hour notice of approaching storms or ice is needed to prepare rigs, and in extreme cases to evacuate personnel, while precision forecasts on a time scale of a few hours are called for by helicopter pilots planning regular or emergency flights. An assessment of the quality of forecasts available to industry off the East Coast of Canada shows a need for improvements in their accuracy, their content, their analyses and their transmission; nevertheless, existing forecasts are recognized as being the best currently available.

One of the fundamental obstacles to effecting improvements in forecasts is the lack of sufficient real-time observational data. This is data which is observed and reported immediately as opposed to being stored for subsequent analysis or distribution. Although all operating rigs are part of the observational network, the present real-time coverage of weather in the offshore area of eastern Canada is far below that available for land-based forecasting.[2] The scarcity of observing stations in the open ocean is a common problem all over the world, and a number of solutions are being proposed. One of the most promising developments is the application of satellite-borne technologies to collect data by remote sensing over large areas of ocean.[3]

[2]A project was recently launched off eastern Canada to assess the usefulness of inexpensive, small, moored buoys measuring only atmospheric pressure and sea temperature as a means of adding to the observing network. Buoys were moored at three sites along the southern flank of the Grand Banks. They transmitted data via satellite to the Atmospheric Environment Service throughout the winter of 1984.

[3]Satellite-borne instruments include a scatterometer which is capable of measuring wind speed and direction over large areas of sea and an imaging or synthetic aperture radar which can penetrate fog and cloud cover. Canada has undertaken a project called RADARSAT which will launch a remote-sensing satellite by 1990. The purpose of this project is to collect observational data in the Northwest Atlantic which is not available at present. Final selection of sensors has not been made, nor have orbit or other details been finalized pending identification of user requirements.

Another fundamental problem facing meteorologists which has some repercussions in forecasting for offshore regions is the refinement of the present synoptic or large-scale marine forecast to take account of mesoscale or mid-scale phenomena. These phenomena include squalls and polar lows that are capable of producing hurricane force winds, yet they extend over a small enough area to go undetected by the network of observing stations. Squalls are known to be associated with narrow bands of precipitation embedded in the structure of a low pressure system. The bands may be as narrow as 20 kilometres and extend over as little as 100 kilometres, with life cycles as short as 2 or 3 hours, yet wind velocity changes of more than 50 knots can occur within the band. The physical nature of mesoscale phenomena is not fully understood and this factor is hampering the development of models capable of usefully forecasting mesoscale events. This problem is receiving attention worldwide, and a major study of the East Coast area, the most comprehensive study of storms ever undertaken in Canada, has recently been launched. A prominent feature of this study, the Canadian Atlantic Storms Project (CASP), is that it is a joint meteorological and oceanographic venture.[4] Projects of this nature hold considerable promise for improving forecast quality along the Atlantic seaboard and consequently for promoting the cause of safety offshore.

There are also other ways of improving the quality of forecasts. Verification, for example, determines how well a forecast measures up to the actual conditions experienced at the site. The results of verification procedures are important in establishing the level of credibility of a given forecast service. The verification procedures used by the private firms servicing offshore areas of eastern Canada and the Atmospheric Environment Service (AES) are, at present, not always consistent with one another, a situation which should be rectified. The interpretation of existing forecasts on board the rigs also needs improvement. Methods of forecast presentation could be upgraded through the use of television and computer technology which would provide two-way visual communication between sea and shore permitting the transfer of more detailed information in a more useful form, and rig personnel should be better trained in interpreting environmental information.

The hostile nature of the marine environment offshore eastern Canada leaves no room for complacency on the part of those who would operate industrial endeavours within its reaches. A solid foundation of environmental knowledge and its perceptive analysis form the only logical bases for sound decisions affecting all aspects of design, construction and operations. Those scientists who seek to decipher this complex environment and to offer guidance to offshore administrators, consider most aspects of this marine climate inadequately documented. This situation holds particularly true for analyses of 100-year or extreme events which require long periods of high quality data. But the extent and reliability of the data base itself are only part of the problem. There are also agreed-upon weaknesses in the present system of managing, analysing, and disseminating marine environmental data to prospective offshore users.

The entire information process is an intricate one – from the initiation of a program to the application of results, through publication to final archiving of properly processed original data in an accessible data bank. It involves questions of proprietary rights, restricted access, relevance to user requirements and the need for some

[4]The meteorological objectives of CASP are to study the movement and evolution of large scale storms that affect the area; to understand the processes responsible for and the characteristics of mesoscale features embedded within these storms; to examine the relationships between storms and the ocean and between storms and ice fields; and to develop forecasting techniques using satellite and weather radar data for severe winds and precipitation associated with these storms. The oceanographic component of this project will study the relationship between currents, waves and local winds, as well as the behavior of storm waves in shoaling waters. The field program is scheduled for the early months of 1986 to coincide with a corresponding United States experiment called GALE. Together these studies will provide a unique data base for numerical modelling studies of storm evolution along the Atlantic seaboard.

sort of co-ordination between government and industry in the planning, collecting and managing of this resource. The Canadian Petroleum Association has recently proposed that industry and government begin to address future environmental data needs offshore by establishing a task force to develop a co-ordinated data management system. A joint approach of this kind would meet the requirements of both users and regulators and should not be postponed.

As more information and better analytical techniques become available, environmental maps similar to those issued for the North Sea by the United Kingdom Department of Energy could be developed, kept up to date, and distributed regularly. These steps should effect significant improvements in the level of certainty to be ascribed to design and operational criteria and, by extension, in the maintenance of offshore safety.

4

DESIGN AND CONSTRUCTION

CHAPTER FOUR DESIGN AND CONSTRUCTION

The design of a mobile offshore drilling unit is intended to create a functioning machine which as closely as possible can meet the requirements of the owner for efficient drilling under specified environmental conditions within the framework of relevant regulations and classification society rules. The development of drilling units has depended upon and pressed forward the "state-of-the-art" of many engineering, industrial and marine disciplines. The rapid growth in the scale of operations and the parallel evolution of designs to cope with increasingly remote and demanding environments have challenged the ingenuity of all those who participate in and regulate the offshore industry. To assess the suitability of a rig for these environments, it must be determined whether the methods and principles applied in MODU design establish an adequate level of safety, whether MODUs are built to an acceptable standard and whether they can be operated safely under adverse conditions. An analysis of the procedures followed in building rigs reveals the potential for the wide variations in quality that are to be expected in a rapidly evolving international industry operating under a number of different regulatory regimes.

In light of past tragedies and of increased drilling activity in offshore environments which are not fully understood nor well characterized, a basic practical issue is the suitability of MODUs to operate on the Canadian Continental Shelf. As these rigs arrive in our waters with widely varied design, construction and operating histories, it is imperative that the principles and regulation of their design and construction be examined and that it be determined to what extent the Canadian regulatory agency can rely on international practice in establishing adequate standards of safety. After that examination, it is then necessary to decide the extent to which, and the methods by which, an adequate standard of safety is assured and is maintained on all rigs under Canadian jurisdiction. The physical environment off eastern Canada tests structures and systems severely; if their quality and suitability for operation in that environment cannot be assured by international practices, then the regulatory authority of the Coastal State must obtain that assurance through the most appropriate means.

Both fixed and floating MODUs have operated successfully in eastern Canadian waters. Drill ships have been used in the Davis Strait, in the Labrador Sea and on the Grand Banks; jack-ups are employed on the Scotian Shelf, and semisubmersibles remain the most widely used rigs for exploratory drilling offshore Nova Scotia and Newfoundland. Floating MODUs are expected to function safely and efficiently in this hostile Northwest Atlantic climate, to maintain their position within a few metres relative to a wellhead with a minimum of motion during drilling and to accommodate the loading and movement of materials while maintaining their draft and trim. Jack-up rigs must stand firm against the forces of wind, wave and current

4.1 Of the twelve MODUs drilling off Canada's East Coast in May, 1985, seven were semisubmersibles and five were jack-ups; there were no drill ships operating in the area at that time. Submersibles have never been employed on the East Coast, although ice-reinforced submersibles have been used successfully in the relatively shallow waters of the Beaufort Sea.

while drilling, and yet make a safe transition to a free-floating state in order to change drilling locations.

A MODU design will be replicated only a limited number of times, usually by a number of different builders, and even units built to the same overall design will vary significantly in detail in order to take advantage of new technology and to meet the requirements of regulators and individual owners. It is the rig owner who must ultimately assume full responsibility for the quality and safety of the MODU that he owns and operates. Nevertheless, the ultimate level of safety is also dependent upon contributions made by others, including those involved in its design and construction, and in its inspection and certification. One factor upon which these contributions are significantly dependent is the extent to which each party communicates with the others and participates in the planning, development and operation of a MODU.

The working arrangements among those who design rigs, those who build them, and those who ultimately own and operate them are varied. The designer may be part of the organization of a rig owner, he may work with a shipyard or rig builder or he may operate independently. The extent and quality of the communication between the designer of the rig, the shipyard that builds it, and the owner who operates it will vary for virtually every project. In many instances the designer will participate in modifying the design to meet the owner's requirements and the constraints of construction, and in assisting the owner in supervision and inspection; the designer's involvement may, however, terminate with the sale of the design to an owner or builder (Appendix C, Item 1).

Normally, a rig owner with a design capability in his own organization will first prepare a set of specifications, based on anticipated developments in market conditions, including a description of the rig's proposed operational capabilities and of the environments in which it may be required to operate. In many instances these requirements can best be met by adapting an existing design with a proven record of operations. Otherwise the more lengthy and expensive process for a new design will be initiated.

Independent designers and those who work for rig builders usually develop a conceptual design to meet the general requirements of owners working worldwide in diverse offshore areas, and modify the plans as necessary so that it can be built effi-

4.2 Of the 773 MODUs working, under construction or planned in September, 1984, there were 463 jack-ups, 180 semi-submersibles, 91 drill ships/barges and 39 submersibles. The largest concentration of MODUs at that time was in the Gulf of Mexico, where 199 rigs were in operation.

ciently in shipyards with different capabilities and equipment. The design concepts are marketed to prospective clients on the basis of inherent competitive advantages and their adaptability to particular needs and requirements.

Whatever may be the designer's arrangement with the builder and owner, it will rarely be known with certainty where the rig will drill for more than the first few years of its active life or the manner in which it will be operated and maintained. He therefore designs a rig that is capable of operating safely and efficiently in the most extreme environments which the owner may specify, that can be built at a competitive cost, that meets all requirements of the selected classification society, and that meets the requirements of the Flag State and of as many Coastal States as practical. Between the often conflicting requirements for operational flexibility, cost and regulatory compliance, there are trade-offs in which potential theatres of operation may be sacrificed to enhance competitive advantage in more certain markets.

The design process for a rig is, like most engineering design processes, an elaborate iterative one in which many variations of structural arrangements and configurations may be explored. The operating capabilities of the MODU are first clearly defined and a conceptual design is accordingly formulated. The concept becomes the subject of extensive analysis, as the designer combines personal judgment and past experience with mathematical and physical modelling techniques in an effort to reach an optimum design. Structural strength and stability are examined to ensure both the integrity of the rig under various loading and environmental conditions, and its compliance with relevant national regulations and classification rules. Motion characteristics are estimated and compared with the operational criteria, towing resistance and propulsion requirements studied, and modifications to the concept analysed to determine their overall effect on performance and cost. When the conceptual design has been accepted, a preliminary design is developed by naval architects, structural engineers, mechanical and electrical machinery specialists, and experienced operational personnel. A classification society is generally consulted during this stage or even earlier, and, as the design becomes more definite, approval in principle is sought from the appropriate bodies involved in the regulation of the drilling rig, in its classification, and in its operation. Finally, the designer will prepare a set of engineering drawings and written specifications to enable the owner to call ten-

ders for the rig's construction. Although this may represent the end of the original designer's involvement, it is important to realize that it does not mark the end of the design process. A significant portion of the design is, in fact, carried out by the builder and by the owner. The builder is usually responsible for developing all the working drawings and detailed design work necessary for construction, and may carry out this work with little or no guidance from the original designer. The owner, through the provision of "owner-furnished equipment", actually influences the design of large portions of the rig. The entire drilling and well control systems, for example, are usually owner-furnished.

During the design and construction of a rig the society selected by the owner to class the rig assumes increasing involvement as an independent inspector. During the preliminary design phase, the classification society will have analysed the design and issued an approval in principle. After a contract for construction has been let, the society, under contract to the builder,[1] will approve the method of construction and the working drawings developed from the original design and, in consultation with the builder, establish an inspection and testing plan for approval by the owner. Based on statistical data from new constructions and annual surveys, a sampling of welds will be selected for non-destructive testing. Elements and connections which are critical to the structural integrity of the rig will be singled out for testing in excess of that proposed for sections of lesser importance.

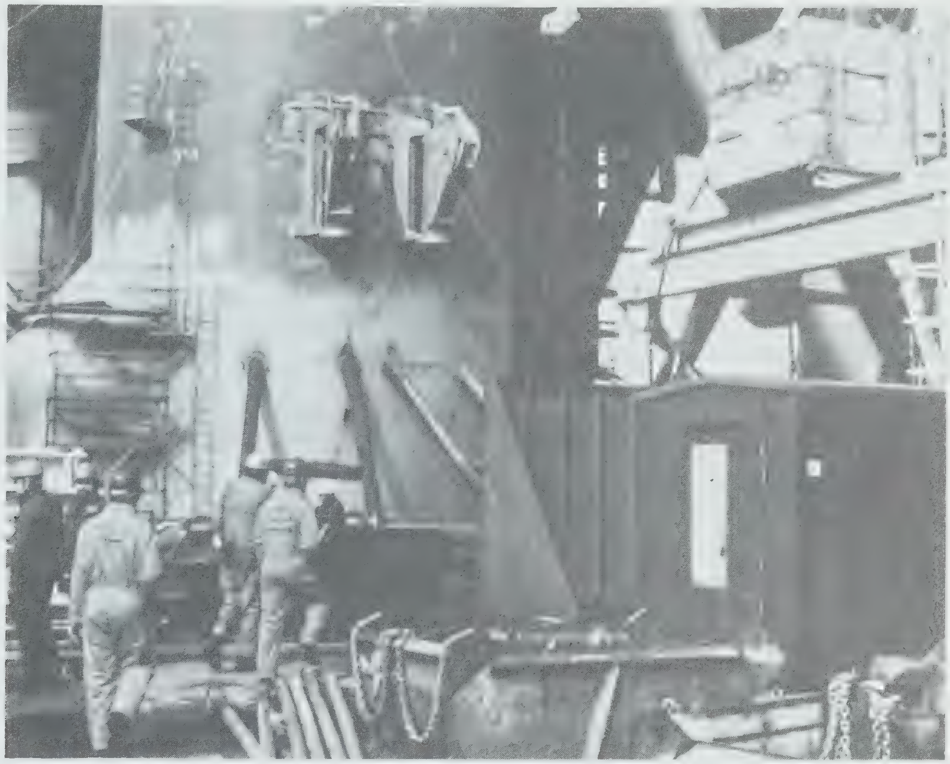
The classification society carries out its inspection and approval role only to the extent necessary to ensure compliance with its rules. What the owner may request, in addition to this inspection and the quality control practised by the builder, is entirely a matter of choice. The level and extent of the involvement of owners in supervision, inspection, and quality assurance during construction varies widely, ranging from those who will commit significant resources to the task to those who will essentially delegate all responsibility to the shipyard and the classification society.

During construction the detailed design of the MODU will continue to evolve as day-to-day decisions are made to improve construction scheduling and efficiency, reduce cost and enhance the safety and performance of the final product. All changes which affect the items covered by classification will normally be referred to the society's representative at the site, and all changes are subject to the approval of the owner. In many cases, changes will be the subject of negotiation between the builder, the owner's representative and the classification society's inspectors. Even after the rig has been subjected to an inclining test, dock and sea trials and has been approved by the classification society and appropriate national regulatory bodies, outfitting may remain to be completed and minor changes may still be underway when the rig arrives at its first drilling location.

A number of documents will be prepared to assist the owner in the safe and efficient operation of the rig. Although the classification and regulatory requirements for the extent, quality and approval of these documents varies, an operating manual and construction portfolio constitute the essential minimum to be provided. The operating manual should outline the operating limitations of the rig implicit in its design criteria, the operating procedures necessary for its safe operation and all other relevant information. The construction portfolio should contain a complete set of "as-built" drawings together with directions for the frequency, location and extent of the inspections necessary to confirm the rig's structural integrity throughout its active life.

The new MODU joins a world fleet of nearly 800 others. Many of the rigs now being designed and built are specifically intended for drilling in harsh environments, cold weather and deep water; some may eventually drill in Canadian waters, as may

[1]Although the classification society is selected by the owner on a competitive basis, the society is generally retained and paid by the builder. The approval of the finished unit by the selected society is a condition of the contract between the owner and the builder.

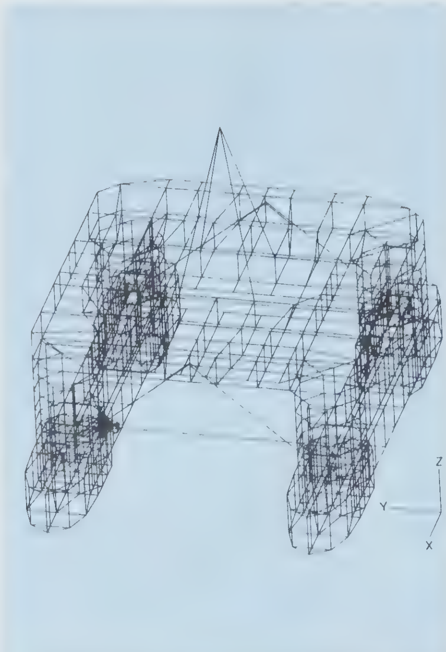


4.3 The construction of a new MODU is a complex operation involving hundreds of skilled tradesmen. A high standard of quality assurance is necessary during the construction process to achieve an acceptable level of safety.

other older rigs from the existing fleet. Their ability to operate safely is contingent largely upon the success of the design and construction process through which they have been created.

Designers, and the classification societies which approve their work, are faced with many uncertainties in predicting the strength and behaviour of the finished unit from the detailed analysis of the design. The limitations of existing analytical techniques, the inherent uncertainties in the conversion of environmental forces to loads and stresses in the structure, the potential for flaws in materials and construction techniques and, ultimately, the limitations of those who will operate the rig, must all be addressed. Most of these difficulties are counteracted by the use of adequate safety factors for the structural members and connections that are critical to the rig's integrity, and by incorporating a level of redundancy in the structure which, in the event of a failure, will allow loads to be carried through alternative components. Safety factors must be recognized as a means of reducing risk where uncertainty exists and as a legitimate method of compensating with subjective experience for shortcomings in analysis and in construction.

The rules of classification societies and, often, the regulations of Flag and Coastal States require that a design be capable of withstanding a specified set of environmental conditions. The prospective owner may, for a variety of reasons, stipulate more rigorous conditions. To develop a design that meets these requirements, the designer will employ a variety of analytical and design methods, some explicitly suggested or required by regulatory bodies or by classification societies, some a matter of the designer's choice. Individual designers will, through experience, have greater confidence in some techniques or procedures than in others. The analytical or experimental techniques, however, by which environmental conditions are converted to loads or forces on the rig, involve simplifying assumptions that make possible the analysis but also introduce uncertainties in the results that they yield. Furthermore, it is often difficult to determine the vulnerability of a design to a combination of conditions, each less severe than the specified extremes. The extreme forces may not be



4.4 Mathematical and physical modelling techniques continue to evolve with improvements in computer technology and in the understanding of the behaviour of full-scale structures. Nevertheless, both methods involve uncertainties which can affect the overall safety of a rig's design.

those that have the greatest effect on the structure. Jack-up rigs have suffered fatigue damage in their legs, and semisubmersibles in their trusses, in wave conditions far less severe than the extremes for which they were designed. Both designer and classification society need to agree on a number of load cases that are representative of the worst loadings to which the unit will be exposed in actual operation. It is recognized that it will not be possible or necessary to analyse every conceivable load case.

Physical model tests can provide important information on the strength, behaviour and stability of a structure and supplement or complement the results of other purely analytical techniques. Physical model tests, however, as do the analytical approaches, involve many simplifying assumptions and limitations. While they are intended to reproduce real operating conditions and appropriately scaled physical members of the rig, they cannot reproduce all the complexities of the full-scale structure, the environments in which the rig will operate, or the combinations of conditions to which it may be exposed. Many difficulties are encountered in establishing the scaling factors necessary for adequate simulation. The differences between model tests, mathematical modelling and real-life behaviour will be better understood and the predictability of behaviour improved when more attention has been given to full-scale, real-time instrumentation, monitoring and testing of operating MODUs for which model-testing data are available (Appendix C, Items 2, and 6).

Simplified procedures and general yardsticks have been adopted in certain areas where the theoretical basis for assessing a MODU's behaviour is either inadequate or so complex that it is of little practical use. This has been done in the determination of the wind-related forces and of the resultant heeling of semisubmersibles. Experience has shown that this simplified approach provides a reasonable factor of safety, and comparisons of the forces calculated using this empirical method with model-testing data have indicated the approach to be somewhat conservative. There is, however, a lack of a firm and rational basis for these empirical yardsticks, and a lack of agreement regarding theoretical approaches to the problem.

With the increasing use of higher strength steels, and with more sophisticated and apparently accurate methods of structural analysis, the designer today can significantly reduce the weight of the rig, and increase its operational efficiency with

attendant commercial advantages. High strength steels, however, call for more sophisticated welding methods and materials, more accurate lineup and fitting, and better control and inspection than conventional steels. While the newer methods of analysis may be more accurate and permit more efficient designs, the level of quality assurance must be more stringent in order to maintain acceptable standards of safety. None of the methods available can give assurance that all loadings to which a MODU may be subjected can be accounted for analytically in the design process. Nevertheless, these analytical tools do allow the identification of critical elements in the design and of the areas requiring intensive inspection.

The development of new concepts and techniques in design and in their supporting analyses, which are almost invariably computer-based, enables the designer to explore quickly the effect of changes in his design and in the magnitude and frequency of applied loads. These new techniques provide a capability to reduce some of the uncertainties in earlier designs and to achieve a reduction of weight and cost while enhancing the potential performance of a design. Similarly, the application of these techniques may allow designers to accommodate fully new and more severe code requirements with little, if any, change to the design and thereby to avoid increased costs. Only with time, experience and the careful monitoring of operating rigs, however, will justifiable levels of confidence in new concepts and techniques emerge.

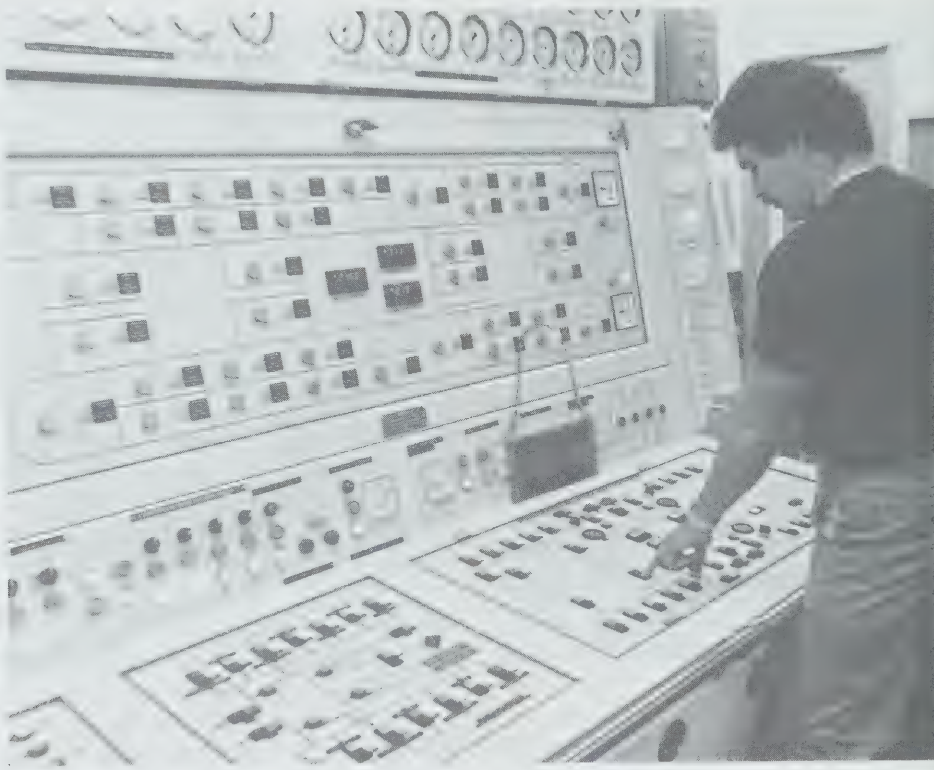
Whatever the type of analysis that is employed, it is significant that some of the assumptions made by the designer in order to carry out the analysis may pass through the approval process without being challenged. The result has proven disastrous on a number of occasions. The sinking of the semisubmersible *Transocean III* in the United Kingdom sector of the North Sea in 1974 was directly attributed to an erroneous assumption regarding the transmission of loads from the legs to the main structure. No lives were lost in that incident, as the crew were evacuated six hours before the rig capsized. The loss of the semisubmersible *Alexander L. Kielland* in the Norwegian sector of the North Sea in 1980 was attributed to the failure to identify, in the structural analysis or during construction, the stress concentration that was caused by a hydrophone support opening in a primary bracing member; the result was the failure of the bracing member under conditions that were within the rig's design limitations, the subsequent separation of an entire column and the loss of 123 lives. These two examples indicate the serious results of human shortcomings that may be present and the need to ensure that the assumptions made in the design and construction process are independently challenged and subjected to intense scrutiny. It is a sobering reminder that both the *Transocean III* and the *Alexander L. Kielland* were in class, had been approved by their respective Flag States and had been inspected by the Coastal States under whose jurisdiction they were operating.

"Certifying Authorities should be reminded of their obligations to make a critical scrutiny of all design details and, in particular, to question and verify the applicablity of all assumptions made in the course of design – this is of particular importance where designs or design details involve unusual or novel conceptions."

Recommendation from the Report on the Loss of the Drilling Barge Transocean III. UK Department of Energy, Petroleum Production Inspectorate. 1975

With the selection of the design, the owner fundamentally assumes the responsibility for establishing the quality of the rig, its safety and its efficiency in operation. His selection of the yard in which to build the rig, the extent of his involvement in supervision and inspection and the level of supervision during construction have a great influence on the quality of the constructed unit. In many cases the designer retains little, if any, control over the detailed design carried out by the builder, or over the selection and integration of owner-furnished equipment. The extent to which these design and outfitting processes are analysed to ensure overall compatibility varies widely; isolated acts by the builder or owner, which when taken individually appear inconsequential, may produce unexpected vulnerabilities in the overall design.

An illustration of the importance of the owner's and builder's influence on design can be taken from the investigation of the loss of the *Ocean Ranger*. The design specifications for the rig described a ballast control panel with simple manually operated pneumatic valves. The builder subcontracted the detailed design and assembly of the panel to an outside firm which proposed the addition of an electrical



4.5 The complex interaction between human operators and the systems under their control requires careful consideration during the design process. Schematic control panels, such as the ballast control panel illustrated, have been replaced by computer control systems and video display terminals on some new rigs. Some of the factors affecting the "man-machine interface" are addressed in Appendix C, Item 3.

control system to operate the pneumatic valves. This design was accepted by the owner as being equivalent to that described in the specification, even though the less complex manual valve panel had been installed on the owner's earlier rigs and had performed well in operation. The vulnerability of the *Ocean Ranger*'s electrical control system to flooding was a major factor which contributed to the loss of the rig. Whether the same outcome would have resulted if the design specification had been met and a pneumatic panel installed, was answered in February, 1984 when a second ODECO semisubmersible, the *Ocean Victory*, sustained wave damage which ruptured a portlight and deadlight assembly in the ballast control room and resulted in the ingress of water. A United Kingdom Department of Energy memorandum on the event concluded that "it was fortunate that in the case of *Ocean Victory* the ballast controls were pneumatic and therefore not affected."

An examination of the roles of the designer, owner and builder in their search for more reliable, more efficient and cost-effective structures has revealed extensive evidence of vulnerabilities produced by a lack of attention to the human element of MODU operations. The level of safety achieved by concentration on the rig's structural integrity may be substantially eroded if control systems and equipment are not designed with consideration for the way in which the operating personnel receive and respond to information, the manner in which the information is processed and used and the factors which modify or alter the response of individuals to the critical processes under their control. This "man-machine interface" is often compromised by equipment design and layout based solely on engineering requirements; features of the detailed design of systems critical to the MODU's safety may limit or preclude their operation under foreseeable adverse circumstances. Many of these limiting features were discovered during the inquiry into the loss of the *Ocean Ranger*. There should be no ambiguity for an operator about the status of a critical valve, its location or how to operate it manually, if the need to do so should arise. Furthermore, in the event that the rig is damaged and listing, the limited ability of anyone to perform tasks on a tilted surface which is in constant motion, should be recognized and

should govern the design, location and orientation of critical controls and equipment with which the operator must work. Expertise in this field of "human factors" has been readily available for many years, but its application in MODU design is not yet a common practice.

The role of the builder in determining the level of quality and thus the ultimate safety of the rig cannot be overemphasized. Even though during construction the rig is inspected by a classification society and often by the owner, in the final analysis the effectiveness of this process will depend to a great extent on the builder's own quality assurance program, on the skill of the design staff and on the competence of the workers. As many MODU designs differ radically from conventional vessels in the materials, methods and complexity of construction, the builder's previous experience with MODUs is crucial. The contemporary use of higher strength steels has been accompanied by advances in welding techniques, materials handling and alignment tools; nevertheless, stresses in the structure induced during construction and flaws in materials and welds that may have been present in earlier units may not be as easily forgiven by nature in new and leaner rigs destined to operate closer to their design limitations in severe environments. Even the best designs can be compromised in construction.

A rig is designed and constructed in accordance with the rules of the classification societies, international conventions and the regulatory requirements of the Flag State. Although they differ in some respects, the major classification societies are generally similar in their function and in the responsibilities that they assume. They, on behalf of rig owners and associated interests such as insurers, machinery suppliers and steel makers, establish rules relating to design, construction and materials for different classes of vessels and carry out analyses of designs and inspections of new construction, modifications, maintenance and repair to assess compliance with these rules. In the formulation of their rules and in their inspection procedures, they draw upon long experience, a large pool of statistical data, and extensive research and development capability.

Meeting and maintaining compliance with class rules is usually a requirement of the owner, the insurance underwriter and often of the Flag State.[2] It signifies that the vessel complies with a standard of construction which assures structural strength for the conditions for which it was designed; that particular electrical and mechanical systems comply with the rules and are installed properly; that the vessel is maintained by its owner to the extent that it does not lose its classification, and that all major repairs or structural changes on the vessel are carried out in accordance with the rules of the classification society.

Classification assures that the design and integrity of the main structure and certain of the systems of a MODU are adequate according to the societies' rules, but the classification process does not address many of the systems upon which the safety of the rig may depend. Mooring systems, for instance, which are of critical importance in station keeping and may have to be rapidly disconnected for ice avoidance in eastern Canadian waters, may not always be subject to classification. Communications and evacuation systems, which may spell the difference between life and death during emergencies, are also outside the societies' ambit, as are the drilling and well control equipment, the failure of which may give rise to disaster. Classification rules are primarily oriented toward the MODU's structure and hardware. The overall tendency of the rules regarding equipment is to concentrate on the mechanical and electrical suitability of individual components, and not sufficiently on their integration into reliable and operable systems.

[2]For instance, the Canadian *Interim Standards Respecting Mobile Offshore Drilling Units*, to which all Canadian-registered MODUs must comply, allow the acceptance of the construction standards published by Lloyd's Register of Shipping, the American Bureau of Shipping, Bureau Veritas, and Det norske Veritas, four of the major classification societies.

The choice of Flag State under whose regulations the vessel will be built is normally made before construction begins. Individual Flag States exercise varying degrees of regulatory control over the design and construction of MODUs under their registry. Although stability rules have traditionally been the responsibility of the Flag State, many countries require only that the rig meet the stability criteria of the society under which it is classed, and the issuance of the certificate of registry is often delegated to the classification society. Classification and compliance with the *International Convention on Load Lines* and the *Safety of Life at Sea (SOLAS) Convention* may be the sole requirements for registry. It is significant that both Conventions were developed for international application to conventional vessels, and do not adequately address the requirements of MODUs. The *International Convention on Load Lines*, while applicable to drill ships and transiting jack-ups, cannot be applied logically to semisubmersibles because of their structural configuration. The *SOLAS Convention* deals with the design of a vessel as it affects the safety of life, including communications equipment and lifesaving appliances. That even those MODUs outfitted far in excess of the SOLAS requirements do not provide the means for successful evacuation in foreseeable emergencies is evident from historical record.

Many Flag States require that the standards of the *International Maritime Organization (IMO) Mobile Offshore Drilling Unit Code*, adopted in 1980, be met. Some countries have supplemented the requirements of the *Code*, as Canada has done, while others have introduced requirements that depart sufficiently from the *Code* to establish, in effect, a new regulatory regime; Norway moved in this direction when she introduced, as a result of the loss of the *Alexander L. Kielland*, among other requirements, the provision that a semisubmersible be able to survive the loss of buoyancy equivalent to that of a main column. Many dispute the current approach of relying on the buoyancy of the deck structure to comply with Norwegian requirements in that the watertightness of the deck relies heavily on efficient closing appliances and on absolute adherence by the crew to operating procedures. Both of these assumptions have proven fallible in the past. The design requirements for a watertight deck may also limit the number and location of emergency escape routes which can be provided to the perimeter of the unit. In the opinion of many, these dramatic departures from the established principles of the *IMO MODU Code* may not necessarily contribute to the overall safety of those involved in offshore operations.

"Realization of realistic criteria for leak [sic.] stability for some types of platforms will lead to requirements for making some parts of the deck structure buoyant. . . . To use (part of) the deck of conventional platforms as buoyant elements in a leak or damage condition, is. . .to a great extent to be considered as a new principle. Introduction of new types of platform may also represent changes of the conditions of operation."

The Alexander L. Kielland Accident. Norwegian Public Reports. March 1981

Although no losses of semisubmersibles have been attributed to inadequate intact stability rules, the differences in the rules are evident from the tables in Appendix C, Item 4. An example where agreement among regulatory agencies is desirable is the calculation of the effects of wind forces on MODUs. The methods vary considerably, although the procedures for calculating wind heeling moments contained in the most specifically formulated rules are said to be adequate and conservative. There is no uniformity in the requirements for the minimum metacentric height (GM) and not all regulatory agencies limit the maximum static angle of heel in wind. All the individual intact stability requirements combined are necessary to provide a reasonable safety factor for the stability of a drilling rig; GM is directly related to the forces that act to restore a heeled MODU to its level position, and is determined by the shape of the submerged parts of the rig and by its centre of gravity in a given operating condition. An increase in the minimum required GM, which may result from changes to one or more of the existing intact stability requirements, will reduce the carrying capacity of a MODU at a given draft with a consequent need for more frequent resupply.

The existing rules worldwide, regarding the ability of a semisubmersible to remain stable and afloat after sustaining damage and flooding of watertight compartments also show differing opinions, primarily in the assessment of the extent of damage for which allowance must be given and in the establishment of the maximum

4.6 Numerous collisions have been reported between drilling rigs and supply vessels on Canada's East Coast. Supply vessels must manoeuvre in close proximity to the outer periphery of a rig during cargo transfer and anchor-handling operations. Many rigs are equipped with fenders to limit impact damage. This photograph of the *Ocean Ranger* at transit draft shows the fenders high above the waterline.

angle of inclination which may result from that damage. Most authorities have based the extent of damage to be considered on the credible consequence of impact with a supply vessel, as this represents its most likely source. As supply vessels operate near the outer perimeter of the rig, only those watertight compartments on the outside of pontoons and columns are considered; no provision is made for protection against the impact of ice, which may occur on the inner periphery of pontoons and columns. This problem requires early consideration for units operating in ice-frequented waters. Although the *IMO MODU Code* does not define a specific angle of inclination which may result from the assumed extent of damage, the Canadian *Interim Standards Respecting Mobile Offshore Drilling Units* limit the allowable angle to 15 degrees.

A further difficulty in most current damage stability regulations is that they assess downflooding only on the basis of the static inclination caused by the damage and a specified wind force. They do not take into account the motions of the semi-submersible and the action of waves on it. Stability rules currently require a MODU to be designed so that, under the specified extent of damage and wind conditions, it will not list beyond the angle of downflooding, which by definition is the angle at which an unprotected opening in the structure reaches the mean sea level. Because rig motion and wave action may cause downflooding long before that point is reached, codes should include provision for freeboard to potential downflooding points, or for reliable weathertight closures to protect openings that may be immersed.

Jack-up rigs are particularly vulnerable during long tows since they are not always able to avoid severe storm conditions. Their freeboards are normally quite low and because of their typically short and blunt hull shapes, their motions in rough seas are large. Considerable green water can be shipped over the deck in a storm, with the potential of causing damage to deck fixtures, or shifting of cargo with resultant damage and downflooding. While there is a growing trend to transporting jack-ups to new locations aboard barges, more attention should nevertheless be given to the weather- and watertight integrity of these rigs.

4.7 The jack-up drilling rig *Dan Prince*, 600 nautical miles south of Alaska while under tow to West Africa in October, 1980. Hurricane-force winds and high seas battered the rig for six days before it eventually capsized and sank. The sinking was attributed to flooding caused by structural damage and by the shifting of deck equipment and cargo.

MODUs designed and constructed as discussed above, are governed by international conventions, the rules of classification societies and the requirements of their Flag State. The fundamental question for the Coastal State, upon whose continental shelf they are intended to operate, is whether a particular rig is suitable for operating under the environmental conditions prevailing there. The Coastal States under comparative review have each answered this question in a different way.

In the United States, the approval of MODUs is regulated by two agencies, the United States Coast Guard and the Geological Survey. The Coast Guard carries out inspections to assess the rig's structural integrity, stability and compliance with rules which incorporate the standards of the American Bureau of Shipping (ABS), the American National Standards Institute, the American Petroleum Institute and others. Certain assessment and inspection activities may be delegated to ABS for any United States-registered rig that it has classed. Foreign flag rigs are required either to possess a valid certificate of compliance with the *IMO MODU Code*, or to submit to Coast Guard inspection for the issuance of a letter of compliance which indicates that an equivalent level of safety has been established. The Geological Survey has additional requirements to establish the fitness of a MODU to withstand oceanographic, meteorological and seabed conditions.

In Norway, the Norwegian Maritime Directorate or a delegated body such as Det norske Veritas, conducts an assessment of any existing rig, or rig under construction, which is proposed for operation in Norwegian waters. The survey is conducted to assess compliance with the *Mobile Drilling Platform Regulations*. After the rig has been accepted, intermediate surveys are carried out annually in addition to an extensive review and inspection every four years.

The United Kingdom has instituted a process for the approval of MODUs to ensure that all aspects of the design and construction processes are subjected to critical scrutiny by an independent body, after which a *Certificate of Fitness* is issued for the intended area of operation. The regulatory authority has approved six certifying authorities to carry out the survey, five of which are classification societies. To date, only the classification societies have issued certificates, and, in most cases, the society doing so had already classed the rig. The certification process is carried out to assess compliance with an extensive set of performance standards entitled *Offshore*

Installations: Guidance on Design and Construction and generally referred to as the "Blue Book".

The Canadian approval process for MODUs has changed significantly since the loss of the *Ocean Ranger*, just as the Norwegian process was altered after the loss of the *Alexander L. Kielland*. When the *Ocean Ranger* was proposed to operate on Canada's East Coast in March, 1980, the Canada Oil and Gas Lands Administration (COGLA) accepted the rig on the basis of its classification certificate, *SOLAS* and *International Load Line* certificates and its *Certificate of Registry* as a United States vessel. No surveys were conducted by a Canadian regulatory authority to ensure that the rig was suitable, in an overall sense, to carry out operations on Canada's Continental Shelf. COGLA performed inspections only to the extent necessary to confirm that the drilling program itself was carried out in a safe manner conforming to good oilfield practice.

Since the loss of the *Ocean Ranger*, COGLA has required that all MODUs intended for operation in Canadian waters comply with the *Interim Standards* and, through a Memorandum of Understanding, has given authority to the Canadian Coast Guard to inspect rigs for compliance with these standards. The standards essentially embody the requirements of the *IMO MODU Code*, with the addition of more stringent requirements for stability and ballast control in reaction to the loss of the *Ocean Ranger*. Canadian-registered rigs must also comply with the requirements of the *Canada Shipping Act*, and all rigs must comply with the requirements of the *Canada Oil and Gas Drilling Regulations* and their accompanying guidelines.

The central focus of the present certification process in all four jurisdictions is the structural integrity and stability of the rig. The assessment also includes such items as emergency power, fire protection, communication, lifesaving equipment, and maintenance of equipment. But the safety and hence the suitability of a rig for operations on the Canadian Continental Shelf will depend not only upon the physical integrity of the rig and its equipment but also upon its critical systems and upon its management and crew. To this end, what is necessary is a three-phase safety audit or approval process; one for each of the essential criteria of suitability. The first phase should consist of an assessment of the physical integrity and the stability of the rig; the second should be an evaluation of the operability and integration of its critical systems; the third should constitute an assessment of the qualifications and competence of its management and crew

Before the first phase can begin, a comprehensive body of regulations and guidance notes needs to be developed against which a rig is to be assessed. The Blue Book in the United Kingdom and the *Mobile Drilling Platform Regulations* in Norway provide a broad scope of requirements, which make clear, both to the inspection agency and to the owner of the rig, what is required for approval. Canadian requirements are less developed and less comprehensive than those of the other jurisdictions examined and they need to be reviewed and in many cases amplified with particular attention to design; standards of material and of construction; hazards from environmental conditions, especially ice and icing; evacuation and lifesaving systems; station-keeping and mooring systems; and preventive maintenance. Of particular concern is the fatigue strength of certain structural members exposed to vibrations, the effect of which it is difficult to predict. Welded connections between struts and columns are especially vulnerable and closer inspections of them would be advisable. It is interesting to note that, in 1982, the Newfoundland and Labrador Petroleum Directorate developed design and construction regulations, that drew upon those of other jurisdictions under review but supplemented them in such areas as drilling equipment, mooring systems and environmental conditions, particularly ice. In the formulation of the needed comprehensive body of requirements to assure the physical integrity and the stability of the rig, the Canadian regulatory authority should draw upon the expert advice available in other government departments and agencies, con-

sult closely with industry and adapt to its special needs the knowledge and experience of other nations.

The assessment of a rig to determine its compliance with requirements and guidelines is often delegated, in whole or in part, to classification societies, in Norway to Det norske Veritas, and in the United States to the American Bureau of Shipping. In the United Kingdom, as stated above, classification societies have been used to certify the rigs proposed for use on its continental shelf. The logic of the British approach is that technologies of MODU design and construction are rapidly evolving and their scrutiny needs experienced practising professionals supported by multidisciplinary resources of personnel and testing facilities. Since external agencies possessed these resources, the decision was taken not to develop the capability within government. In Canada, there has been no delegation to external agencies and rigs have been assessed by the Ship Safety Branch of the Canadian Coast Guard. With the introduction of more detailed and broader requirements, it would appear advisable to utilize the classification societies with their long experience, their reservoir of statistical data and their extensive investigative resources rather than to attempt to develop an in-house capability to determine whether a rig complies with the requirements which govern its structural integrity and its stability. The classification society would certify to the regulatory authority that all regulations have been met and all guidance notes followed. This assurance of compliance would constitute the completion of the first phase of the safety audit or approval process.

The second phase of the safety audit or approval process should be an evaluation of the systems identified as being critical to the safety of the rig, of the interrelationships and interactions among these systems, and of the procedures governing their operations against the environmental conditions of the proposed drilling site. These systems should be subjected to a level of analysis consistent with their potential impact on safety. Before an evaluation can be undertaken, there is need of a clear, comprehensive set of performance standards and criteria, drawn up by the regulatory agency in consultation and collaboration with industry, against which an evaluation can be made.

Because the nature of the assignment is quite different from that of the classification societies, it is not recommended that the second phase of the safety audit be performed by them. This second phase of the approval process should be carried out by a safety audit team appointed by the rig owner, subject to the approval of the regulatory authority. It should consist of persons whose personal judgment is supported by extensive experience, who have demonstrated knowledge of offshore operations, systems reliability and risk analysis, and who are well grounded in all aspects of safety management. The function of the safety audit should be one of seeking improvements rather than of laying blame, of assessing the consequences of inadequacies, and of evaluating remedial measures necessary to improve the safety of operations. This objective can be fully achieved only when the owner incorporates it as part of his own program for quality assurance and safety. The appointment of the auditors by the owner should assist in the attainment of that goal.

All drilling units operating or intended for operation on Canada's Continental Shelf, whether existing or new construction, built in Canada or abroad, should be audited for safety. The rigs to be audited will generally be those already in existence and intended for operation in Canada. Since it would be neither fair nor practicable to have the owner bring a rig into Canada, only to have it subsequently rejected, the major portion of the safety audit should be done within the six-month period before its intended arrival in Canadian waters. It is recognized that special consideration may have to be extended to rigs which have already been approved and are operating on the continental shelf but "grandfathering" should be kept to a minimum.

The second phase of the safety audit or approval process should not duplicate the assessment of the structural integrity and stability of the rig that was completed

4.8 The extreme environmental conditions encountered off Canada's East Coast demand that particular attention be paid to the adequacy of the critical systems, personnel, and operating procedures of each drilling rig.

during phase one. The safety auditors, nevertheless, would be expected to discuss with the appropriate representatives, any matters of concern which might arise out of the review of the documentation. The first task of the safety auditors would be the gathering and assimilating of information with respect to the rig. This documentation should include all available information about the rig, its design and construction, its critical systems, its management and crew. It should also include a critical review of, *inter alia*, all certificates issued under phase one of the approval process and other documentation required in order to enable it to operate; the operating and emergency procedures manuals, the operational history of inspections and modifications, preventative maintenance logs, the crew training program, personnel qualification requirements, and administrative procedures. The audit team would also be provided with all documentation pertaining to the assessment of the physical integrity of the rig carried out in phase one of the approval process. Should their examination of this documentation or other evidence reveal inadequacies, independent analyses as well as thorough inspections and assessments of the structure and equipment could be required.

The review of documentation should be followed by an inspection of the rig. In addition to the inspection of equipment and systems and the assessment of their functional performance, the auditors should assess the extent to which actual operating procedures comply with those intended by management. When deficiencies are identified and recommendations for improvement considered, the safety auditors should discuss with the owner, the operator and the regulator how the deficiencies can be addressed, the urgency of doing so, a schedule for any agreed remedial steps, and restrictions that may be imposed during the intervening period.

The report on the second phase of the safety audit or approval process should identify any feature of the rig that would preclude or unduly inhibit its safe operation under foreseeable circumstances on the Canadian Continental Shelf. The report should be submitted to the rig owner, the operator and the regulator. The report may unconditionally certify compliance of the unit, categorically reject it, or conditionally

4.9 Recent blowouts on the Scotian Shelf, on the semisubmersible *Vinland* and the jack-up *Zapata Scotian*, were attributed to a combination of mechanical failures and human errors in the operation of well control systems. Both incidents illustrate the need for a closer examination of the design and operability of the critical systems used on MODUs.

certify compliance, recommending that the issuing of permits or permission to proceed beyond certain defined milestones or dates be dependent upon the completion of specified modifications, or upon the institution of changed operating procedures. Upon receipt of a satisfactory report, the regulatory authority should issue a conditional approval. The owner will have assurance that the rig will be permitted to operate when it arrives in Canada or, alternatively, he will have the option of not bringing it to Canada, if he is not prepared to correct those deficiencies identified by the safety auditors.

The third phase of the safety audit or approval process should be carried out by the safety audit team after the rig is in operation in Canadian waters. It should be directed towards confirming that any deficiencies or vulnerabilities noted in the safety auditors' report and required by the regulatory authority to be rectified or remedied have been satisfactorily attended to. It should then be directed to an assurance that the approved operating procedures for the safe operation of the rig are being followed by a competent and qualified crew. This review should include an assessment of the training, knowledge and qualifications of those involved in the control and operation of critical systems and the effectiveness of these individuals in performing both routine tasks and emergency drills. This assurance is necessary because of the common practice of making significant crew changes when a rig moves from one jurisdiction to another. Upon receipt of a favourable audit report, the regulatory authority should issue an unconditional Certificate of Approval.

Other audits may be deemed necessary, whether after a fixed number of years or upon a proposed move to a location of greater environmental hazards. The need may, indeed, be dependent upon the outcome of the initial safety audit or may arise from the operating experience and the occurrence of "significant events". The scope of these audits should be determined after full consultation with the owner and with the operator.

The importance of establishing a clear understanding of the responsibility and accountability of each of the parties involved in offshore petroleum activity under

Canadian jurisdiction cannot be overestimated. The increasing complexity of the industry has led to contractual and organizational arrangements within which dilution and diffusion of responsibility and of accountability for safety can readily occur. There should be no confusion regarding the responsibility and the accountability of the rig owner and of the operator.

The rig owner should unequivocally be responsible for the integrity of the rig and accountable for its safe operation. This responsibility requires that he be satisfied with the quality of construction and that all reasonable steps be taken to identify construction flaws that may adversely affect the safety of the rig; to ensure that the rig complies with the design principles, performance standards and criteria set out by the regulatory authority; to arrange for audits as required by the regulatory authority to establish compliance with its standards and criteria; and to report to the regulatory authority, as required, those incidents that may have endangered equipment or personnel, or revealed a need for change in equipment or operating procedures.

The operator is legally accountable for all aspects of the operations under his permit. It is he who hires the MODU and, from that fact, he cannot escape responsibility for its quality and its performance. Ultimately he has the power, through the contractual arrangements into which he enters, to influence the safety consciousness and performance of the contractors whom he retains. It is the rig owner who should be clearly responsible for the fitness and safety of his drilling rig, and his contract with the operator must reflect his responsibility to manage and maintain it in an acceptably safe condition that complies with the requirements of the regulatory authority.

The knowledge, capabilities and commitment to safety of all those involved in the many diverse functions required to operate a drilling program offshore eastern Canada will, in the final analysis, determine the safety of the drilling rig and its crew. No equipment, however well designed and built, subjected to the demands of these offshore marine environments, can be made impervious to human error or fallibility. Ultimately, safety depends as much on people as on the soundness of the equipment.

5

MANAGEMENT

CHAPTER FIVE MANAGEMENT

It has long been understood that the safe and efficient operation of any industrial enterprise depends on far more than the physical integrity of the plant and equipment. Each venture encompasses a myriad of diverse elements, both inanimate and human, which it is the task of management so to combine that every hand, as well as every working part, should perform co-operatively, and that every operation, whether routine or rare, should proceed with ease, order and success. That the quality of the management process plays a vital role in assuring the safety of offshore exploration is abundantly clear; accident reports are replete with descriptions of counteraction and confusion stemming from managerial misjudgment, operational inadequacies and basic human error.

A harsh environment or weaknesses in design or structure will rarely, in themselves, cause offshore accidents; there is always an operational component involved as a contributing factor. In several recent rig and supply vessel accidents that occurred during storms, a major problem was the lack of proper operating procedures for preparing for heavy weather – a porthole deadlight not shut, a rig not deballasted to survival draft, a deck load not tied down or a crew not trained to cope with the unexpected. Many of the causal connections in the web of circumstances surrounding an offshore accident are the small, routine matters of rig housekeeping that play a vital and sometimes decisive role in the promotion of safety awareness and in the protection of human lives (Appendix D, Item 1). Other management involvement comes on a larger scale when, for example, well control is lost, and the sudden threat of fire, explosion or toxic gas makes quick and correct action imperative. Blowouts are a major cause of casualties during drilling operations and investigative authorities have again and again cited as a primary contributor, the failure of management personnel to follow effective well control procedures.

The early years of this decade saw three major rig disasters and the shock produced by this series of catastrophes led to substantial changes in operating procedures and in equipment standards. That these improvements are beneficial cannot be denied; yet they alone cannot secure the safety of the men and machinery on a drilling rig off the East Coast of Canada. Advanced technology or elaborate response plans serve little purpose without competent human control. In fact complex systems or strategies may prove harmful if uninformed use is made of them, or if people are lulled into complacency by their presence. An ice alert plan may well designate safety zones and prescribe appropriate response, but recent events have shown that these plans are not infallible and that there remain a number of key points in that process where the action taken by rig management may stand between safety and potential disaster. While improvements in design, equipment and operating procedures are to be encouraged, undue reliance on them could induce a lack of appropriate vigilance

and hence heightened risk. The fundamental, overriding factor affecting human safety offshore is intelligent human control over the use of equipment and procedures and over the complex process of management that welds these elements together to form a working whole.[1]

The key management issues affecting operational safety are familiar both to regulators and to those actually involved in offshore management. There must be, for each drilling rig, a straightforward chain of command, established qualifications for the person in charge, and a clear allocation of responsibility and accountability for safety matters which involves every member of the rig community. There must be, for each drilling rig and for the industry in general, clearly defined and well understood operating guidelines, contingency plans, and reporting procedures for all matters affecting the safety of the rig or its crew. There must be, for each drilling rig, competent supervisors and a capable crew who are appropriately selected, organized and trained for the tasks they are to perform.

These issues have been addressed by industry, particularly since the loss of the *Ocean Ranger*, and many improvements have been effected or promised. Questions remain, however, regarding the thoroughness and consistency with which these basic tenets of responsible management are being observed in the offshore workplace. There are indications, for example, that two recent blowouts on the Scotian Shelf were both caused by management error involving, in one case, "hesitancy in following the operator's emergency plans" and in the other "serious error in interpreting drilling parameters and failure to react in a proper and expeditious manner."[2]

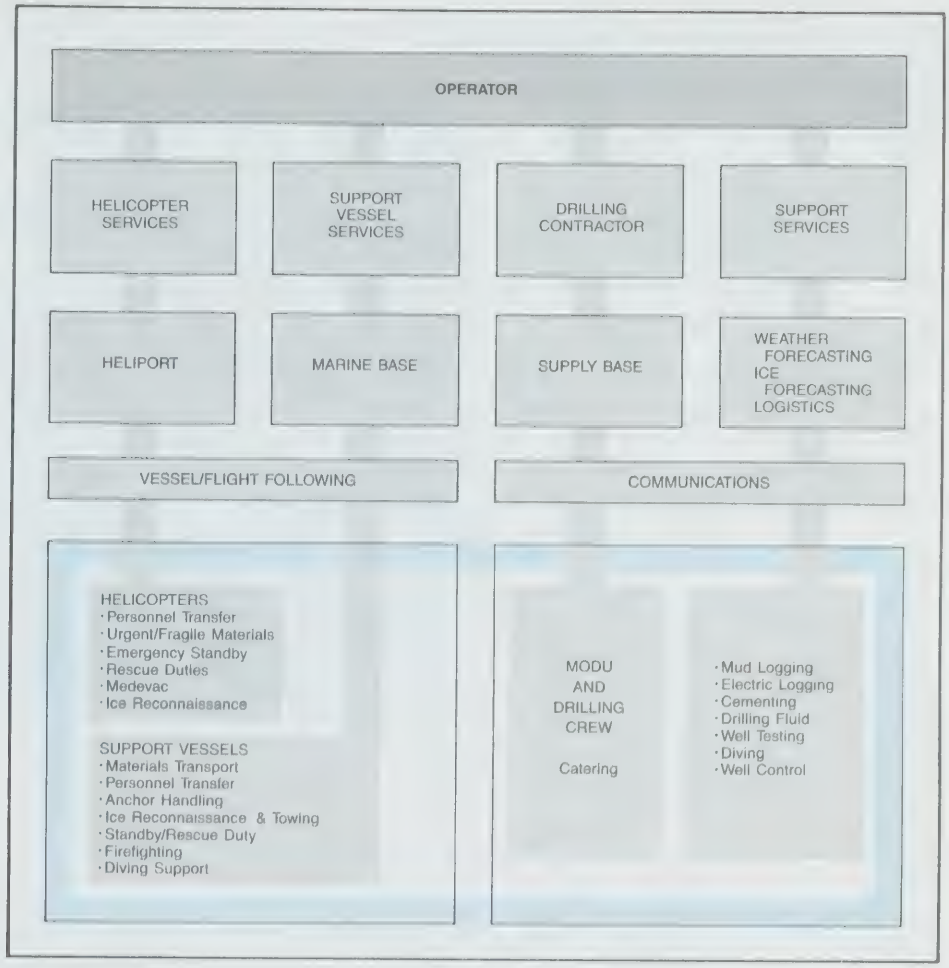
The main participants in the management of eastern Canadian offshore drilling operations are the operating oil companies having leasehold rights to drill the exploratory wells and the drilling contractors who own the rigs and carry out the drilling programs. Recognizing the diversity of practice in an international industry and the problems inherent in attempting to regulate the human elements of an operating system, regulators have placed the onus on operators and drilling contractors to demonstrate that their activities are conducted safely.

The operating oil company that undertakes a new drilling program is at the apex of a pyramid of contractual relationships since a variety of organizations are retained to provide a wide range of services to the project. The standard practice during exploration and delineation drilling off eastern Canada is for operators to retain drilling contractors to drill their exploratory wells. Most of the drilling contractors are large companies who own substantial fleets of MODUs and drill wells for oil companies all over the world. The drilling contractor is expected to provide a suitable rig that is managed and manned by appropriate personnel. The regulatory authority must be satisfied that the drilling contractor retained by the operator is experienced and that the drilling rig to be used is satisfactory for the site and for expected environmental conditions. The drilling contractor is then held responsible by the operator for fulfilling the terms of their contract, while maintaining the safety of men and equipment and observing applicable regulations.

[1]Analyses of offshore incidents generally attribute the lion's share of accidents to operational errors. The International Association of Drilling Contractors' "Charlie Report" (1982), for instance, cites 1,231 offshore accidents in U.S. waters, 891 or 72 percent of them caused by "unsafe acts" as opposed to "unsafe conditions". These findings are consistent with those found in other jurisdictions and other years. The Foundation of Scientific and Industrial Research of the Norwegian Institute of Technology's *Risk Analysis – Accident Experience,* 1980 presents a detailed analysis of 31 one- or two-person fatalities on board offshore installations, and concluded that their most frequent cause was "human error". The Newfoundland and Labrador Petroleum Directorate's *Risk Analysis of Drilling Units Operating Offshore Newfoundland and Labrador* 1983 and the Burgoyne report on *Offshore Safety* in the U.K. (1980) also point to the high proportion of accidents attributable to human error.

[2]Energy, Mines and Resources, Canada; Indian and Northern Affairs, Canada.
Report of Investigation of Events Culminating in a Blowout of Gas and Condensate at Shell et al Uniacke G-72. June, 1984
Report of Investigation of Events Culminating in a Loss of Well Control at Mobil et al West Venture N-91. April, 1985

5.1 The operator contracts a wide range of services in support of the drilling program. Each contractor may have specific management practices and methods which are dissimilar to those of the operator.

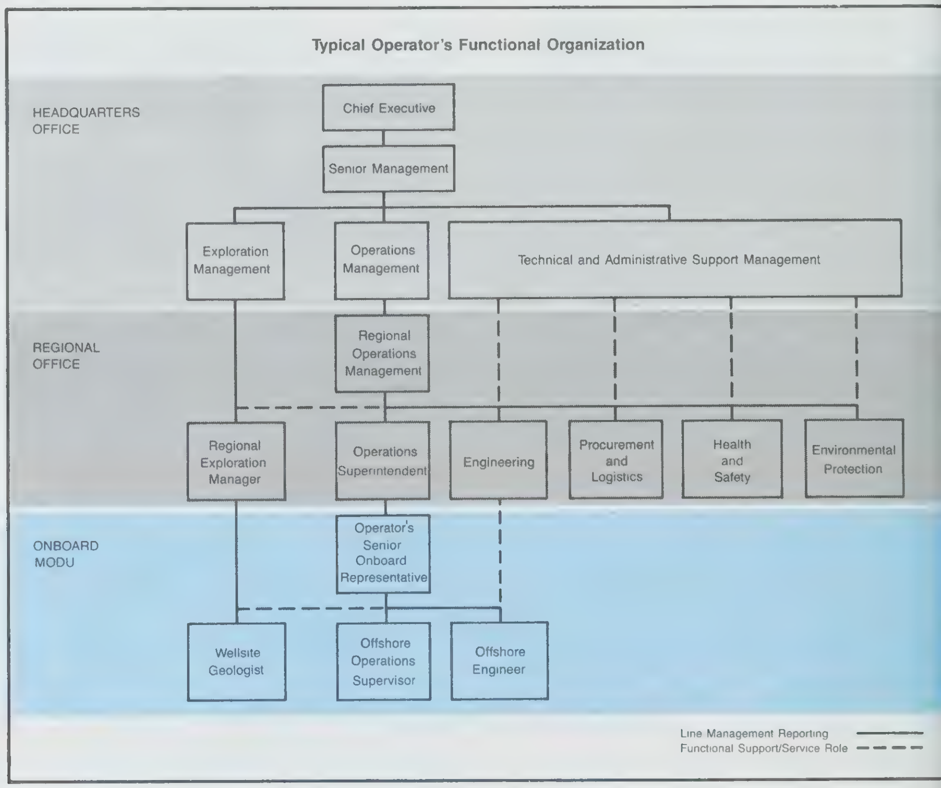


Services directly related to the operation of the rig, such as catering, are normally subcontracted by the drilling contractor. All other services are contracted directly by the operator. Materials and supplies are transported to the rig by supply vessels which also perform anchor-handling, iceberg-towing and standby duties. A helicopter service carries workers, mail, and urgent supplies to the worksite and undertakes evacuation and rescue duties. Other specialty services involve divers and diving support equipment, ice observers and weather forecasting, and the various well services necessary to the drilling operation including mud-logging, electric-logging, cementing, and well-testing. A sophisticated communications system links both the operator and the contractor with their respective shore bases and head offices.

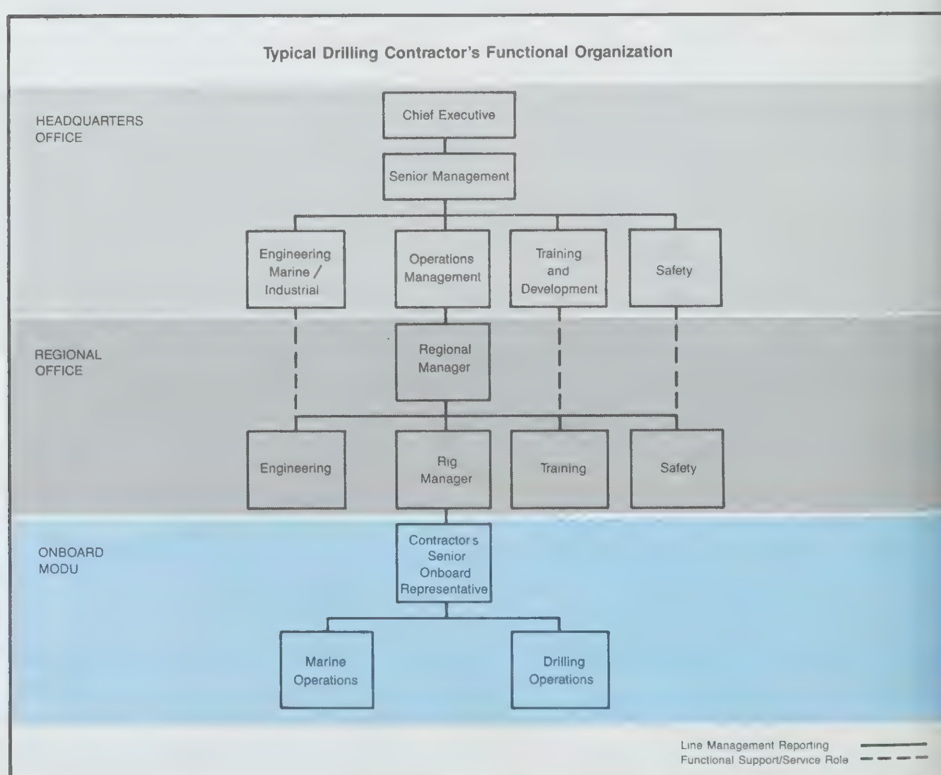
The operator is accountable to the regulator for the physical integrity of the rig that is hired to undertake the drilling program, for the performance of its management and operating personnel, and for the health and safety of everyone employed on or involved in the operation. Even though each contractor is bound by the terms of his contract to operate at all times in accordance with applicable Canadian laws and regulations, the operator is ultimately responsible for every aspect of the project, whether undertaken by his own employees or by those of a contractor or subcontractor. The operator's responsibility goes far beyond a passive reliance on others to meet the requirements of the law and public policy.

Both the operator and the drilling contractor maintain a line of authority that flows down from head office through a regional office to senior representatives on board the rig. The regional level for each organization has specific management duties for all the rigs under its jurisdiction. The operator's regional manager will

5.2 The operator's organization is divided into three distinct levels, involving personnel at the head office, the regional office and on board the MODU.



5.3 A typical drilling contractor's organization.



ensure that the exploratory drilling program is carried out within budget and with due regard for human safety and protection of the environment by overseeing the operation, by providing and co-ordinating the logistic and technical support required, and by maintaining liaison with regulatory agencies and with other operators in the area in respect of resource sharing and emergency planning. In the event of an emergency, he is responsible for co-ordinating action and support. It is highly desirable for the operator's regional manager to have had prior experience as an operator's senior representative on a MODU. In that capacity, he would have gained a knowledge and understanding of reservoir characteristics, borehole dynamics, drilling fluid chemistry, fluid flow dynamics, abnormal pressure detection, and well control theory and practice, as well as some appreciation of the problems that can arise in the marine environment. This would ensure that he has the appropriate technical knowledge to understand the nature of the difficulties that the operator's senior representative on the rig may face and the decisions he may have to make or share. If an emergency should occur, the regional manager, while relying on the judgment of the onboard representative, must be ready by reason of temperament, training and experience to cope with the problems that will be thrust upon him.

The drilling contractor's regional manager is responsible for monitoring activities on board the rig; ensuring that the unit is fully manned with appropriately qualified and trained personnel; establishing effective safety management and training programs for all on board; and maintaining the rig and its equipment in good repair. Most drilling contractors have had considerable experience operating offshore, yet they, like the operators, have their roots in land-based drilling operations. Consequently the emphasis on the industrial aspects of offshore operations has tended to overshadow the need for a complementary marine component in their onshore management teams.

The managerial partnership of operator and contractor continues on board the rig itself. The operator's senior representative on board the rig is known by a variety of titles, including offshore drilling foreman, superintendent, supervisor, or offshore operations supervisor. Whatever he may be called, he is the operator's manager at the drill site, who is responsible for the well and for seeing that the drilling program is followed and that the objective of obtaining as much geological and reservoir information as possible from the well is met efficiently and safely. In this capacity, he conveys to the senior representative of the drilling contractor the operator's requirements with respect to the drilling program, including decisions on running casing, cementing, logging, production testing, and well control. He co-ordinates and directs the activities of the various on-site contractors who supply specialist services, ensures through his regional office that supply and transportation services are provided to the rig as required and is responsible for seeing that such other support services as weather, ice forecasting and surveillance are functioning satisfactorily. In discharging these responsibilities, he will consult regularly with his regional management or with senior operating management at head office, but he remains the person responsible at the drill site for all operating decisions affecting the project and the well. During an emergency, he will consult with the person in charge of the rig and provide advice, support, and co-ordination of the contracted resources and services.

From the standpoint of operational efficiency and of safety, it is preferable to have critical operational decisions made on the drilling rig where the best information is available and where decisions can be made quickly. Therefore, it is essential that the operator's senior representative on a MODU be qualified in all aspects of managing a drilling program during normal and emergency operations. Generally, those who attain this position do so after gaining a considerable amount of experience and training as a drilling engineer or after working their way up through the operator's drilling department. This training and experience, normally received on land rigs, should be supplemented with extensive experience on MODUs. In terms of

both day-to-day operations and emergencies, the presence of a competent and knowledgeable individual in this key position will often have a substantial influence on the efficiency and general safety standards on board a rig.

The overall manager of the rig will be the senior representative of the drilling contractor. This responsibility will lie with one of two senior positions, the toolpusher who heads the drilling operation or the master who is in charge of marine matters. One person is designated by the drilling contractor as the person in charge of the rig, and the background and experience required for that designation will vary according to the type of rig, the country of registry, the corporate policies of the drilling contractor and the regulatory requirements of the Coastal State. Some semisubmersibles are operated according to the Norwegian model with the master remaining in overall charge, while others operate according to the United States model with command switching between the master, while the rig is in transit or during a marine emergency, and the toolpusher, while drilling operations are in progress. The variety of these arrangements stems from the evolution of the industry from its land-based roots to the marine environment and the genuine differences of view among knowledgeable people as to whether the industrial or marine aspects of the operation are the more crucial.

The toolpusher is in charge of and fully responsible for all aspects of drilling operations, subject only to the advice and direction he receives from the operator's senior representative on the rig under the terms of the drilling contract, and from the person in charge of the rig where he does not hold that designation. The toolpusher directs the work of the drilling crew and is responsible for the operation, maintenance and repair of all drilling equipment and ancillary systems. He is responsible for the training and development of the drilling contractor's industrial personnel and for safety management with respect to drilling in the course of normal operations and in emergencies. A toolpusher will usually have reached his position after working for a number of years as a member of a drilling crew and subsequently as a driller in charge of a crew. His experience and training are likely to have been gained on the job and through courses provided by his company or by industry training schools.

The master is responsible for marine aspects of the operation and for marine safety management. Under normal conditions when the rig is on the well, the principal marine aspects consist of supporting the drilling activity by maintaining the rig on station and minimizing its motion; keeping the platform level at the appropriate draft; transferring equipment and supplies to and from vessels; monitoring the environment, taking appropriate precautionary action to avoid marine hazards such as collision, loss of stability, ice or storms; and training the crew in evacuation and other drills for emergencies. The master will have marine qualifications, but the extent of these qualifications will differ considerably according to the country of registry and to company policy as will the extent of the master's MODU-related training and experience.

While the managerial partnership between toolpusher and master is firmly established within the United States system, it is widely recognized that joint command has, on occasion, led to overlapping responsibilities and ambiguous authority, particularly in emergency situations. The issue of which one to designate as person in charge is further complicated by the nature of the training and experience available in the marketplace today. Because the skills required to manage the drilling operation are similar to those involved in land-based drilling, senior industrial personnel are fairly readily available. Persons with the specialized marine skills needed to take charge of and operate a MODU are much harder to find, and those with the ideal combination of drilling and marine experience as well as innate leadership ability are rare indeed.

While the United States approach may be a practical solution to the command problem it challenges the standard management practice of delegating the direction

of an operation to a single individual who is entirely responsible and fully accountable at all times for all decisions and actions. As in other organizations, supervisors will be delegated responsibility for groups working in each area of expertise with full accountability to senior management. Admittedly, while a drilling rig is free of its moorings or in transit, whether self-propelled or under tow, marine operations are clearly paramount. On the other hand, when the rig is on the well, problems are most likely to occur as a result of industrial hazards such as loss of well control, explosion or fire. It is therefore both practical and necessary for the person in command to delegate authority and the responsibility for a specific aspect of that operation to someone who has the appropriate experience and qualifications. On a MODU, instances will occur where the activity becomes the responsibility of the operator's senior representative, or the toolpusher or the master. Where problems develop with control of the well, the operator's senior representative is generally in charge. Where problems develop downhole in the drilling operation or through equipment malfunctions, the toolpusher is equipped with the technical knowledge and training required to direct the remedial action. When marine-related problems develop such as loss of stability, failure of the mooring system, ice encroachment or storms, it is the master who is best qualified to be in charge. When these eventualities occur, all members of the crew should know in advance from whom they are to take direction. Nevertheless, a single individual should be in command of the rig at all times, however much he may delegate responsibility to others and however much he may consult other key crew members before reaching a decision. To transfer full command in an emergency situation, or to expect lines of communication and authority to switch smoothly from one person to another in various types of emergencies, would seem to defy one of the most fundamental tenets of management, a tenet that has been proven over time and through the course of many endeavours, be they industrial, commercial, governmental or military.

Section 4(o) Person in Command "Drilling units shall at all times have one person on the unit clearly identified as responsible for the safety of the drilling unit and its crew. On floating drilling units this person shall: be experienced in drilling unit operations; and, possess a recognized Master Mariner's Certificate. This requirement recognizes the need for the person ultimately responsible for safety to make decisions in full consultation with the person responsible for drilling operations."

Drilling for Oil and Gas on Canada Lands, Guidelines and Procedures. April 1984

It is a matter of importance that the formal qualifications necessary for an individual to assume the command of a rig in eastern Canadian waters be firmly established and that the position be certified. While certification is not a guarantee of competence, it at least provides evidence that a minimum standard of experience and training has been met. Norway requires that a ship's master be the person in charge of the MODU. He will have completed additional courses in drilling technology and rig manoeuvring and will generally have experience as a ballast control operator, stability officer and first mate before being appointed the person in charge. The United Kingdom designates an Offshore Installation Manager (OIM) for each MODU and production platform but leaves responsibility for deciding the appropriate qualifications and training of the OIM to the rig owner. The United States requires a special Industrial Master's License as the minimum marine qualification for a person in charge of a MODU registered in the United States. While in transit, however, a master mariner must be on board as the person in charge. Holders of the special Industrial Master's License will normally be experienced industrial personnel who have completed a 15 to 20 day training program provided by the United States Coast Guard.

Canada has recently taken a step in the direction of certification by developing a set of draft standards which require all MODUs to be under the command of a specifically designated offshore installation master or manager who must have both marine and drilling qualifications. A person can arrive at this position from either a marine or an industrial background. Marine candidates would receive formal instruction and training in the industrial aspects of MODU operation while candidates with drilling experience would be taught about marine matters affecting the safety of the rig. Before candidates receive final certification, extensive practical experience must be gained in MODU operation. This plan should provide the person in command with a sufficient understanding of the total operation to retain control

5.4 Offshore safety management programs require the constant attention of all crew members and specialist teams to fulfill their emergency roles. Safety meetings and debriefing sessions are held after drills to evaluate performance and discuss deficiencies.

in any foreseeable circumstance, to pass judgment on the performance of those to whom he delegates authority, and to take corrective action if that performance should prove inadequate. This program is seen as a positive step towards resolving the MODU command issue.

A number of steps have been taken by industry and regulatory agencies to improve the overall safety management of MODU operations. The Eastcoast Petroleum Operators Association (EPOA) was initially established as a forum for discussion of operating issues faced on the East Coast and to represent the industry in its relations with governments. After the *Ocean Ranger* disaster in 1982, the Association set up a Task Force on Safety to identify areas of vulnerability and to encourage the institution of corrective actions. In 1983, the EPOA became the Offshore Operators Division (OOD) of the Canadian Petroleum Association (CPA), which now provides operator co-ordination and co-operation in implementing offshore training programs, equipment evaluation and operational programs. The East Coast Operators Management Committee was established by the active operating members of CPA to provide a specific focus for regional operating concerns within the CPA OOD. Through these means, the industry is beginning the process of developing lines of communication between the major operators and various associations of contractors, notably the Canadian Association of Oilwell Drilling Contractors (CAODC) and the Canadian Offshore Vessel Operators Association (COVOA). Their participation on the Management Committee has resulted in improved consultation within the industry and in the contribution by the major contractors to the development of standards in the areas of health, qualifications and training for offshore workers.

Recommendations that were made by the Safety Offshore Task Force Report and accepted by the members of the CPA OOD have the effect of guidelines, although they have not been formally endorsed by Canadian regulatory authorities. There are other areas where the development of a common policy is desirable: for example, it is unclear whether, during discharge of cargo at the drill site, the operational needs of the rig take precedence over the safety concerns of the master of the supply vessel.

Safety management is a matter of attitude and commitment through an organization at all levels. It is a matter of leadership, of sustained and consistent application, of credibility within the organization, of involvement by all employees, of management accountability and of the systematic application of the full range of management methods and skills. It is a matter of information with respect to plans, policies and procedures. It is a matter of ensuring that equipment is properly maintained and that it can be safely operated by those who use it. It is, finally, a matter of participation by workers as well as by management and of providing a mechanism and process for the exchange of concerns and the building of mutual confidence between managers and workers. These principles of safety management are implemented in practice by setting objectives and organizing the means to ensure their accomplishment; by creating physical conditions that are safe; by establishing operating procedures and practices that will reduce risks; by auditing and monitoring performance in all respects; by investigating deficiencies promptly; and by recognizing accomplishments and results.

Most operators and drilling contractors have formal safety programs which reflect a recognition that common sense and programs of minimal safety training are no longer adequate bases for responding to high lost-time accident rates and to the costs associated with those accidents. A safety program at the level of the drilling rig is concerned with good housekeeping in work areas and living quarters, with protecting people from injury by equipment, with fire prevention, and with organizing and training to respond to emergencies. Regular drills and training for all to reinforce basic survival training and special training for emergency response teams in abandonment of the rig and lifeboat operation, advanced first aid, damage control, firefighting, man-overboard retrieval, dealing with toxic gas, and loss of well control are all necessary components of the safety management program. It is incumbent upon the workers and the managers to prevent the development of a cavalier attitude regarding the necessity of this training. Safety management also means involving workers at every level in this overall process. People do not learn to take responsibility without being given responsibility and it is a fundamental tenet of good management that those who are expected to abide by a set of rules or regulations should participate in making them. This principle does more than maintain employee morale; since the person closest to a particular work situation is the one best qualified to diagnose weaknesses, careful attention to worker concerns can often lead to improved efficiency and the early recognition of potential problems.

East Coast operators and contractors have reported on the nature of their safety management programs. Features of these programs include safety policy manuals; guidelines for the safety training of all levels of personnel; participation of workers; hazard identification; policy on the reporting of accidents, "near misses" and abnormal incidents; audits conducted by external non-governmental agencies and bonuses or awards for safety performance. These programs both express and are the instruments for implementing company policy. Certain operators set out required safety and training performance standards for contractors who intend to submit bids and the criteria to be used in examining the past record of the bidders. This procedure is a form of indigenous regulation and should be adopted by all operators.

The operator and the drilling contractor are required to develop, for regulatory approval, plans which outline onboard procedures for normal and emergency operations. These operating manuals and contingency plans describe the procedures that

must be followed to ensure that the well and the rig are secure at all times. These manuals set out an important part of the framework of operating principles within which the managers of the rig make their decisions and against which the management of the operation may be measured in a safety audit process. Managers exercise their discretion in reaching decisions within this framework of operating principles, which provide limits for certain operations and give warning for precautionary action to be taken. The reason for establishing procedures is to ensure a systematic and timely transition from normal to emergency operations. The acid test for contingency plans occurs when problems arise and emergency procedures are actually put into practice. Successful implementation of these plans requires continuing training and rehearsal by all members of the crew and also by those on shore who may be called upon to assist.

Foresight and careful contingency planning can provide the basis for an appropriate response to unplanned events that may threaten the security of the rig and the safety of its crew. Emergencies may be avoided or contained if managers know what to do in various eventualities and can mobilize the necessary resources in time. A clear management structure is a prerequisite to effective communications internally within the rig owner's organization and externally through the operator's organization to support service contractors, other operators, government agencies and regulatory authorities. Alert stages for foreseeable types of emergencies have been designated in advance for ice hazards, deteriorating weather conditions, loss of well control, vessel collision, and helicopter crash or ditching. The procedures to be initiated are defined by industry in consultation with the regulatory authorities, made known to all concerned and included in contingency plans.

Section 79(1) Contingency Plans "Every operator shall ensure that contingency plans have been formulated and that equipment is available to cope with any foreseeable emergency situation during a drilling program, including:
(a) a serious injury to or the death of any person;
(b) a major fire;
(c) the loss of or damage to support craft;
(d) the loss or disablement of a drilling unit or a drilling rig;
(e) the loss of well control;
(f) arrangements for the drilling of a relief well should such become necessary;
(g) hazards unique to the site of the drilling operation; and
(h) spills of oil or other pollutants.

Canada Oil and Gas Drilling Regulations. November 1980

In areas such as the Grand Banks and the Scotian Shelf where several operators are active, the industry has set up multi-operator alert response plans to improve offshore safety through co-ordinated communications and logistic support and each operator has established an emergency command centre. These response plans include a common weather-reporting and iceberg-tracking system, helicopters designated for search and rescue duty, and a central flight-following system which keeps track of all helicopter flights in relation to rig and supply boat positions. The alert plans specify the conditions which trigger a multi-operator alert and designate the equipment and facilities which may be called on in an emergency.

Industry's ability to respond to an offshore emergency has improved significantly since the sinking of the *Ocean Ranger*. Nevertheless, concerns have been expressed about several aspects of emergency preparedness. One area of concern is the decision-making process during an emergency. The person or group of people best equipped in terms of information and expertise to make vital decisions and take action leading, for example, to evacuation, are those on board the rig. Retaining the authority for these decisions on shore may in certain circumstances jeopardize the safety of the offshore installation and crew. A second concern is the type and frequency of training exercises and drills that are presently carried out. Courses that make use of simulated events and exercises, of the kind provided by the offshore industry in the North Sea, would provide opportunities to practise contingency plan procedures, without risk to crew or rig, while at the same time testing the validity of those procedures. They would also provide experience and training to key personnel for the responsibilities that, in the event of an emergency, would be thrust upon them and to persons with understudy roles who may be called on to take charge of particular situations.

A key to successful safety management for both management and crew members is the ability to recognize in advance those abnormalities which may lead to emergency situations. Thorough reports on accidents and incidents associated with unplanned events should form part of the onboard safety system. The regulatory authority should ensure that satisfactory reporting procedures have been established,

5.5 Contingency plans form an integral part of the overall safety management program offshore. In the event of helicopter or supply vessel incidents, approaching pack ice or icebergs, or other emergencies, the operator's contingency plan provides guidance for decision making and the mobilization of personnel and equipment.

since complete and accurate data on any hazardous or potentially hazardous events will prove a valuable aid in effecting long-term improvements in the regulating of safety offshore. The present incident data base is inadequate as a tool for accident analysis or long-term safety planning, and a more rigorous system for reporting, recording and disseminating incident information is warranted.

Safety management programs are generally administered by staff departments which provide counselling and assistance in safety matters to operating managers. Each organization has its own approach but, to be effective, the program must reflect a strong commitment to safety by the chief executive officer and senior management, reaching down through the company to all parts of its operations. There appears to be a growing consensus in favour of co-operative employee/management plans that emphasize initiative by employees on the rigs, actively supported by operating management.

One mechanism which should improve the effectiveness of safety programs offshore is the rig safety committee. Committees have been established on all MODUs off eastern Canada and appear to be working satisfactorily but it is evident that workers do not always feel they are able to communicate freely, to management, their concerns about unsafe working practices and conditions. Workers fear that being overly vocal about safety-related matters may lead to reprisals and possibly dismissal. These attitudes and fears weaken the entire safety management process. A mechanism must be developed whereby the views of workers are accepted openly by management and valid concerns are addressed either on board or on shore. An open, responsive communication channel is necessary if the workers are to play their parts in the detection of hazards and in recommendations for greater safety.

The way in which a drilling program is managed is predetermined by the contractual arrangements between the operator and the contractors. Managing the varied group of persons engaged in the program takes unremitting attention and considerable skill. The mix of disciplines represented in a rig's crew, the widely varying levels of technical expertise among its members, the variety of their national and regional backgrounds, the changes in personnel that result from mobility within the industry as well as from the more regular rotations of the crews, make it difficult to mould this working community into a cohesive entity. A high degree of co-operation

among all those on board and a strong operational team are required if a drilling rig is to function effectively and safely. Senior management must, therefore, be sensitive to the needs of the crew and instill confidence in their own ability to control an emergency should one occur.

The strength of the commitment to safety by the senior managements of the operator and the rig owner will be manifest not only in operational policy and procedures but also in the quality of human relations throughout the organization. In the course of normal operations, safety entails constant alertness and concern to prevent the development of emergencies. The health and morale of the crew, the qualifications and training of all personnel and their suitability for the positions they hold, the dependability of communications systems in adverse conditions, the adequacy of preventive maintenance programs, and the quality of supervision of service contractors are among the variables to be managed in a manner that ensures the safety of the personnel and equipment employed in a drilling program. In the final analysis, the critical factors in safety are the calibre of the crew, the quality of their training, and the level of confidence and teamwork promoted in everyone on board. These factors are dependent on the rig owner's prime operational responsibility to see that a competent experienced person is in charge of the rig, a person capable of giving leadership that embraces an understanding of both the human and the technological dimensions of safety in the offshore.

6

TRAINING

CHAPTER SIX TRAINING

The safe and productive operation of MODUs in the hostile East Coast environment depends critically both on reliable technology and on competent, responsible human organization. In turn, the capacity of the combination of man and technology to function effectively under normal circumstances, to be sensitive to incipiently abnormal conditions and to respond resiliently to emergencies depends critically on the training of all persons involved. Training, whether it be by formal instruction, by the simulation of operations or by experience gained on the job, forms the warp of the fabric of competence and confidence that is essential both to safe operations and to a reliable capacity to meet the unexpected. The weft of this fabric lies in the organization and practices of offshore operations.

At the time of the sinking of the *Ocean Ranger* there were no statutory Canadian standards for the training of persons employed on MODUs operating on the East Coast in any capacity. For example, persons assigned to operate the ballast control system, which is critical to the stability of a semisubmersible, were not required by any regulation to have formal training. Senior drilling personnel were required to have training in well control but the form of this training was not specified. Further, significant variations existed in the standards of training adopted by different operators and contractors. Since then, owners, operators, industrial associations and regulatory agencies both federal and provincial, and indeed international, have properly given renewed attention to the issues of training for safety.

Training for safety for individuals, teams and organizations is a process of continuing development. Within this process there are minimum standards for basic safety training and specialist safety training, that are essential to achieving the level of competence and confidence necessary for work characterized by the peculiar hazards of the offshore. There has been missing in Canadian offshore operations a clear ground for the confirmation and administration of these standards, and a clear definition of the roles of industry, public and private institutions, and government in setting these standards.

Whatever provisions there are for training, either for normal drilling operations or for emergencies, there is the perennial question of the effectiveness of the training provided. The ultimate acid test, is of course, to be found in performance, in the response of individuals, teams and whole organizations to events as they actually unfold. Training, to be well founded, must be effective in the circumstances to be faced.

What understanding ought all persons on drilling rigs to have of the offshore environment? What qualifications ought individuals to have for the basic tasks that they are assigned? By what process of industrial or governmental certification are these qualifications to be categorized? Who should set standards of training? What

balance of processes of training, whether formal instruction, simulation and on-the-job experience, is appropriate? What are the agencies that can and should contribute to training for the offshore? How is the continuing capacity of individuals, teams and organizations to operate safely and productively to be verified? These are some of the inescapable questions about training which demand attention.

The underlying objective of training is to create and sustain in individuals, teams and the organization as a whole, a reliable capacity to perform their duties both in regular operations and in emergencies. The creation of a reliable capacity to perform may be considered to be built upon a combination of competence and confidence. Competence has its roots in native capability, acquired knowledge, ability to analyse, and working skills built up through experience. Confidence is established on the basis of the disciplined and practised exercise of competence in real circumstances. The disciplined exercise of competence in an emergency depends fundamentally on the qualities of leadership displayed by those in charge and on the qualities of co-operative teamwork among the crew of a rig.

"The greatest potential for minimizing the risk of future offshore oil and gas development lies neither in technology nor regulation, but in the abilities, training and performance of the people engaged in the industrial and regulatory activities."

George F. Mechlin, Chairman
Committee on Assessment of Safety of Offshore Continental Shelf Activities,
National Research Council,
National Academy of Sciences, U.S.A.

Knowledge of the hazards to be encountered and against which protection is sought is necessary, if the teaching of safe practices is to be effective. The first category of training, then, that is essential for safe work on drilling rigs is orientation to and understanding of the basic issues of personal safety in the distinctive offshore milieu. This training is basic emergency and survival training. There is universal agreement that persons who visit and work on drilling rigs should have this training adapted in intensity to the roles that they individually are to play. There is general agreement that, for operations in hostile seas, topics to be considered should include hazards of the offshore environment, safety at work, safety and survival equipment, first aid, helicopter safety and emergency procedures, fire control, procedures for rig abandonment, principles of survival and the processes of search and rescue. Among the major international jurisdictions, however, there are distinct differences in the scope of basic safety training and in its regulation.

In Norway there is a statutory requirement that all members of the basic rotational MODU crew undertake a ten-day course in basic safety training. This formal training is required to be supplemented during the first period of employment by instruction specific to the company and the rig. Norwegian practice for basic safety training is one of explicit regulation both in form and in content. The basic two-part course is required to be taken at a training centre approved by government and a significant number of training institutions have been equipped to provide that service.

In the United Kingdom there is no statutory prescription of the content of basic safety training, but there are general duty requirements that all persons working on a rig have suitable training for their own safety, the safety of fellow workers and the safety of the rig. The operator has overall responsibility for safety training. The United Kingdom Offshore Operators Association (UKOOA) has produced, for the benefit of its members, guidelines for safety training, which are accepted and monitored by the regulatory authority. A statutory body, the Offshore Petroleum Industry Training Board, originally established by government as the Petroleum Industry Training Board, has prepared a schedule of courses to meet the UKOOA guidelines. That Board consists of representatives of the operators, drilling contractors, employees, and teaching institutions. Representatives of government departments attend as assessors. The UKOOA guidelines deal with the scope and length of training, the standards to be attained, the methods of certifying the attainment of these standards, and the categories of persons to receive particular training. The situation in the United Kingdom for basic safety training, therefore, is one of monitored self-regulation. The government fundamentally relies on the operators to ensure that guidelines endorsed by the government are invoked by contractors. The Department of Energy monitors this system which is supported by well-established training institutions, both public and private.

6.1 Weekly evacuation drills are held on all MODUs operating off eastern Canada to reinforce basic emergency training. These drills also allow individuals to become familiar with rig-specific escape routes, emergency procedures and equipment.

In the United States there are no statutory requirements for basic safety training. Overall responsibility for training rests with the operator when rigs and their services are contracted. Basic safety training is delivered by operators and drilling contractors through in-house courses, institutional courses, and on-the-job training. The situation is one of self-regulation without detailed government guidelines. There is, consequently, a great diversity of specific approaches.

Section 150.(1) "Every operator shall ensure that every person employed on a drilling program. . . receives instruction and training in respect of all operational and safety procedures that person may be required to carry out during the course of his duties. . . ."

Canada Oil and Gas Drilling Regulations. November 1980

In Canada the situation with respect to training has been complicated by the fact that both the federal and certain provincial governments have issued regulations. Before the sinking of the *Ocean Ranger*, COGLA had not established specific standards for the training of rotational crew. There was a general duty requirement that all members of the drill crew be familiar with the safety procedures that they might be required to perform, that senior industrial personnel have training in well control, and that all persons on the site be familiar with personal safety and evacuation procedures. The responsibility to ensure that these requirements were met rested with the operator.

In response to the loss of the *Ocean Ranger*, the Newfoundland and Labrador Petroleum Directorate required, on an interim basis, that rotational crew members have a Marine Emergency Duties II (MED II) Certificate as defined by the Canadian Coast Guard, or equivalent training. This certificate required completion of a 15-day course devoted, in three parts, to lifesaving, firefighting and rescue/survival. In November 1983, COGLA published guidelines specifying that every member of the MODU rotational crew should successfully complete an approved course. That course was to include helicopter safety and emergency training, rig abandonment

6.2 The hazards of offshore drilling can arise from either the marine or the industrial aspects of the operation.

procedures, survival training and firefighting. However, COGLA issued no guidelines for specific course content. The response of industry during this period was to define the content of what it believed to be a satisfactory basic training course and to arrange for it to be offered. This course was formally endorsed by the industry in its *Offshore Safety Task Force Report* of 1983 and is known as the Basic Offshore Training (BOT) course. Following its decision to require, on an interim basis, the Coast Guard MED II Certificate, the Newfoundland and Labrador Petroleum Directorate in collaboration with the Department of Labour and Manpower worked with the College of Fisheries in St. John's (now the Institute of Fisheries and Marine Technology) to formulate a 10-day course called Basic Offshore Survival Training (BOST). This course is being offered by the Institute.

COGLA has chosen to accept any one of the foregoing courses, MED II, BOT or BOST, as meeting its general requirements for basic safety training, but MED II is accepted only on an interim basis. The significant differences in standards and orientation among these courses is symptomatic of the lack of clarity in the processes whereby standards of training are being established and confirmed. Industry questions the necessity, for all rotational personnel, of a basic safety training course that has a duration greater than five working days. It also questions the necessity of having basic offshore training completed in every instance before offshore duties begin. Underlying the conflict over the duration of basic safety training is the question of to what extent specialized training, for example firefighting, should be encompassed therein.

The situation with respect to the definition and administration of training for safety on the East Coast has been unsatisfactory. The tragedy of the *Ocean Ranger* is a haunting reminder of the importance of training. For the men at risk on rigs today it is intolerable that the means to concert the insights of industry and government on relevant training and to provide for the orderly development and administration of that training remain incompletely defined. Nevertheless, the circumstances are now deemed to be such that significant leadership can be given by all parties.

There is need for a body of competence in training at the regulatory level that has the ability and authority to formulate standards and to accept suitable proposals from industry and institutions for attaining these standards. This body of competence should be obtained through the establishment, on a statutory basis, of an Offshore Petroleum Training Standards Board with a relatively small membership drawn from persons with first-hand understanding of offshore operations and from persons with specific competence in training. The insight of workers having substantial experience offshore should also be represented. This Board should be authorized to determine, in consultation with industry, training institutions and related government agencies, requirements for training in the offshore.

The Board should publish guidelines for course requirements and exercise the authority to accept courses formulated by industry, training institutions and government agencies and to approve staff competence and special facilities required for that training. It should work with training institutions to establish means for evaluating the instructional effectiveness of approved programs. A key part of its responsibilities should be to ensure that means, acceptable to it, exist to verify that required standards of safety training are attained and sustained. Because of the worldwide character of the offshore industry, the Board should have the responsibility to assess the equivalence of foreign training against Canadian standards.

Underlying all questions of training for safety in the offshore is the issue of reconciling the mixture of marine and industrial characteristics of operations. It is natural that industry should emphasize the industrial features and that maritime regulatory agencies should emphasize the marine features of safe operations. What is critical is the melding of these two basic operating cultures in a manner that promotes both dimensions of safety in an evolving industry. For all kinds of supervision,

Table 1
Thirty-Four Basic Rig Positions

CATEGORY	POSITION
Marine	Ballast Control Operator
	Barge Engineer
	Chief Engineer (1)
	Crane Operator
	Dynamic Positioning Operator (1)
	First Engineer (1)
	Master
	Medic
	Radio Operator
	Rig Captain (1)
	Rig Electrician
	Rig Mechanic
	Watchstander
Industrial	Assistant Driller
	Data Management Systems Watchstander (1)
	Derrickhand
	Driller
	Electrical Supervisor
	Electronic Technician (1)
	Floorhand
	Motorman
	Roustabout
	Senior Toolpusher
	Shakerhand
	Sub-Sea Engineer
	Sub-Sea Engineer Trainee
	Toolpusher
	Warehouseman
	Welder
Domestic	Chief Cook
	Chief Steward
	Cook's Helper
	Second Cook
	Steward

NOTE (1) The requirements for these positions depend upon the type of drilling unit and the regulatory jurisdiction.

marine-oriented and industry-oriented, there is need for a dimension of competence rooted in an understanding of the operation and the behaviour of a MODU as both a marine and an industrial entity.

Minimum qualifications and training standards for all the basic tasks to be performed by the rotational crew of the drilling contractor have recently been proposed by CPA OOD in collaboration with CAODC. The thirty-four basic positions are grouped by marine, industrial and domestic categories in Table 1. Table 2 provides the minimum qualifications and training for the positions of master, senior toolpusher, ballast control operator, and roustabout. The provisions for qualifications and training include marine and industrial elements with special training for safety. Reference is made to qualifications for supervisory responsibilities, and for critical technical tasks such as well control, stability control, crane operation, helicopter handling, firefighting, and the use of escape and rescue systems. With respect to the competence of marine rotational crew to work in the industrial environment of a MODU, the Canadian Coast Guard in co-operation with COGLA and Employment and Immigration Canada issued a draft report setting out proposed training requirements for MODU endorsements to marine certificates and also a marine program for industrial personnel. The certification of marine positions such as master, mate, engineer, and able seaman is of long standing and subject to regulatory control. The Offshore Petroleum Training Standards Board should co-ordinate these two proposals and be assigned the responsibility of approving all industrial training endorsements of these positions for service on MODUs.

It is important to distinguish between certified positions and positions for which minimum qualifications and training require certificates of particular skills. For example, in the analysis carried out by the industry, a rig mechanic is required to have an Industrial Mechanic's Certificate, and a rig medic may have a Registered Nurse's Certificate. These certificates are issued by training institutions such as schools of trades and schools of nursing that, in Canada, are approved by the provinces. For a number of positions, the industry has set out minimum qualifications that include specialized forms of training for which there may or may not be associated certificates. For example, a toolpusher is required to have Second Line Supervisors Offshore Well Control training, and a master to have an On-Site Ballast Control Course. Basic safety training is required for all positions and certificates of the completion of existing courses are being issued by the institutions, private and public, delivering the training. Certificates for well control training, which are recognized by COGLA, are being issued by the Petroleum Industry Training Service. Some rig owners provide specialized training for which they issue company certificates.

Mention has been made of differing views regarding the duration of basic safety training courses. This question is related to the extent to which specialist training for firefighting and other emergency tasks is given to all members of the rotational crew. Basic safety training should deal with common issues of safety and instruct all members on the role of specialist teams and the dependence of the safety of non-members on these teams. Specialist training should be concentrated upon individuals who together form teams and who have above average native capability to carry out specialist tasks. Practices and incentives which recognize the importance of the competence of specialized safety teams are to be encouraged. Clear standards for a universal basic safety training course, standards that are firmly administered, coupled with similarly administered specialist training courses for persons selected for their experience and native capability are preferable to an emphasis on point-of-entry training that may attempt to encompass elements best reserved for specialist training. Specialist tasks in which safety is of singular concern include: well control, ballast control, firefighting, helicopter landing, rescue of man-overboard, advanced first aid, and evacuation of a rig. The Offshore Petroleum Training Standards Board

TABLE 2
An Abridged Sample of Industry Guidelines for Minimum Qualifications for MODU Personnel

POSITION	ROLE	PREREQUISITES	TRAINING COURSES (1)
Master	Responsible for the overall safety of Mobile Offshore Drilling Unit and its personnel.	• *Master Mariner's Certificate*, or *MODU Master Limited* or equivalent as determined by the Flag State requirement. • Normally 52 weeks of previous MODU experience. • Demonstrated safety, technical, managerial and supervisory skills, and mechanical aptitude.	BOT IV First Aid (SOFA) H_2S Alert Offshore Fire Team Training Offshore Fire Leader Training CPR Basic Stability Training On-Site Ballast Control Course Supervision Training Management Orientation Maintain MODU Basic Stability Certificate CAODC Home Study Course (Contractor Program)
Senior Toolpusher	Responsible for managing contractors' interest in respect to obligations to clients, the well program and all personnel.	• Normally 52 weeks as a Toolpusher using similar equipment. • Applicable portions of CAODC study courses. • Demonstrated safety, technical, managerial and supervisory skills, and mechanical aptitude. • When designated the person in charge of the MODU, he shall meet the prerequisites specified for the Master and be thoroughly familiar with all applicable regulatory requirements. • First Line Supervisor Offshore Blowout Prevention.	BOT IV *First Aid (SOFA)* *H_2S* Alert Offshore Fire Team Training Second Line Supervisor Offshore Well Control *Offshore Fire Leader Training* *CPR* Supervision Training (Contractor Program) Basic Stability Training On-Site Ballast Control (Contractor Program)
Ballast Control Operator	Responsible to the Deck Officer on watch for control of drilling unit stability, draft and position within prescribed limits.	• An approved industry Ballast Control course. • A rig orientation program of 12 weeks overseen by an experienced Ballast Control Operator. • A complete knowledge of the rig's ballast system as demonstrated by passing a qualifying exam administered by the Master. • Master's approval required for all prerequisites.	BOT IV *First Aid (SOFA)* H_2S Alert *Offshore Fire Team Training* On-Site Ballast Control *CPR*
Roustabout	Responsible for cargo work, maintenance and general labour.	• Entry level position. No prior experience required.	On-the-job training as required by the contractor BOT IV H_2S Alert *Offshore Fire Team Training* *Rescue Craft Training* *On-Site Helideck Crew Training*

NOTE (1) Training programs indicated in italics may be applicable to crew members if they are appointed to a designated team organized to handle a specific task, e.g. fire team, rescue craft team, helicopter landing team.

SOURCE: *Industry Guidelines for Minimum Training Qualifications/Standards (Floating Units Only)*
MODU Crew Personnel for Operations on Canada's East Coast
Canadian Petroleum Association, Offshore Operators Division,
East Coast Offshore Management Committee, Report #103.

6.3 The ever-present danger of fires and explosions requires that highly trained fire-fighting teams be present on all MODUs.

should approve the scope and content of certificated specialist training for these tasks.

There is no clear ground for the elaboration, from present marine custom, of the number of certificated positions. But there must be certification of skills critical to safety in the offshore. The Offshore Petroleum Training Standards Board should, in consultation with the industry, review and approve, for all the positions on the drilling rig, the range of skills for which certificated evidence (or documented equivalent) is to be mandatory. Not least important is a requirement that persons with supervisory responsibilities have the competence to manage emergency situations. It is the industry's prerogative to determine who shall be appointed to what positions. Capabilities to assume particular responsibilities can be developed through diverse paths of experience. Subject to sound, documented evidence that the experience ensures competence in and comprehension of critical areas of safety, diversity of background is not a threat to the integrity of safety offshore.

The public and private resources required to meet Canadian needs for training for the offshore are diverse. Trades and technical colleges, schools of nursing, universities, marine institutes, private firms, and corporate programs all have significant complementary roles to play. It is important that support be directed at ensuring that the component institutions can play these roles effectively and that duplication is avoided.

The need for basic safety training and for specialist safety training is clear and recognized by all concerned. What is required is a responsive framework for defining, delivering, certifying where necessary, and auditing the standards of training for safety. The proposed regulatory focus for that framework is the Offshore Petroleum Training Standards Board. While this Board must have the authority and competence to approve the substance and certification of safety training, to accept courses and certificates offered by different institutions, and to ensure that standards of training are audited, it is anticipated that initiative in the formulation of specific training needs and the transformation of needs into courses and drills can and should come in strong measure from the industry and training institutions. If training institutions are to fulfill this role it is important that their proposals be based directly on their special competence.

The collective initiative of the Canadian offshore industry with respect to training has evolved rapidly from quite old roots in the land-based industry. The East Coast Operators Management Committee has a Training Subcommittee which includes representatives from the CAODC, COVOA, and the Petroleum Service Companies of Canada. The Training Subcommittee is a technical body to which training problems perceived by industry may be brought for examination. A task force of this subcommittee develops the structure of training required to address a particular problem. Where appropriate, training proposals would go to the Offshore Petroleum Training Standards Board for approval and acceptance.

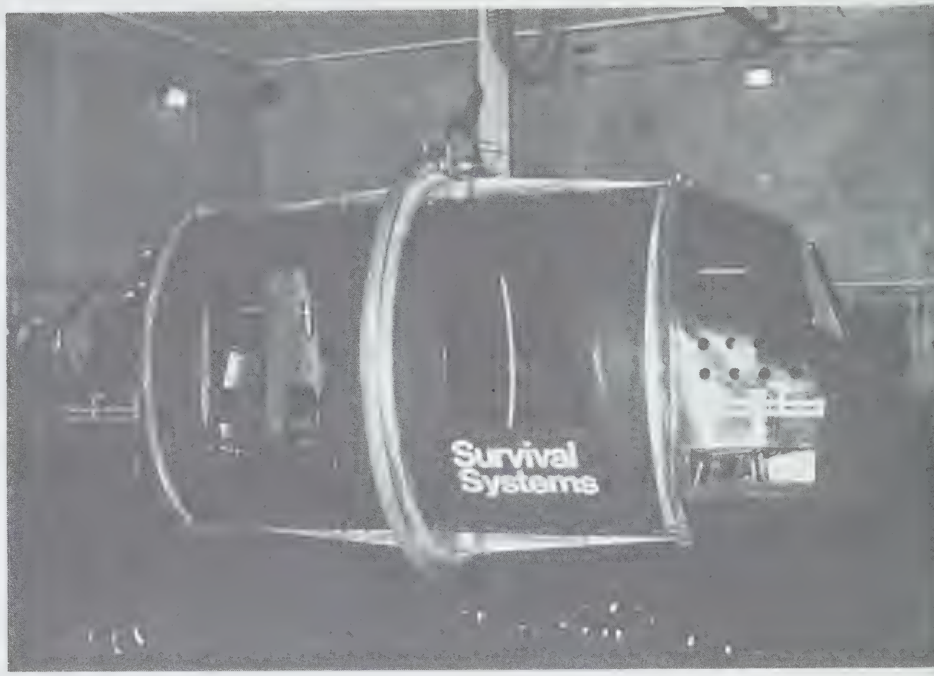
The land-based industry established in 1961 the Petroleum Industry Training Service (PITS) whose role is to facilitate the delivery of training to the industry, and to act as a certifying agent for certain courses. Training standards have been established and reviewed by an examination and certification committee made up of experts from the petroleum industry and from provincial and federal departments of government. By the mid-1970s, PITS had assumed responsibility for issuing certificates on behalf of the industry for training in blowout prevention and well control in land-based drilling. These certificates are accepted by the Energy Resources Conservation Board of Alberta. PITS is now developing an East Coast Division with a management board of senior operating managers. An Examination and Certification Committee for Offshore Blowout Prevention and Well Control has been established and a similar committee for Ballast Control is being set up. Each of these committees will parallel in composition the land-based well control committee.

The BOT course had its origins in the early collective initiatives of the East Coast offshore industry. These initiatives should be sustained as a central part of the framework for safety training. The role of PITS in facilitating the delivery of training, on behalf of industry, and of issuing certificates of training under the surveillance of competent and broadly representative committees, could be recognized by the Offshore Petroleum Training Standards Board, subject to acceptance and monitoring by that Board of the training programs themselves.

The Offshore Petroleum Training Standards Board should ensure that there are regular reviews of offshore training on an annual basis. These reviews should include information gathered directly from representative crew members and reports of incidents that uncover particular points where improved training is indicated. Information on issues of training arising from these reviews should be transmitted to the drilling contractor, to the operator, to PITS, and to training institutions.

The effectiveness of training for safety is reflected in the qualities of competence and confidence that it develops. There are several practical means of testing competence as the underlying basis of confidence. Competence related to normal tasks is developed through experience and is best judged by performance on the job. Competence related to safety can be tested through periodic recertification of specialized training and basic safety training and through practice exercises or drills which simulate emergencies. There is broad agreement that there should be recertification of basic safety training, fire control, well control, ballast control, and other critical elements of training on a cycle of two to three years. The Offshore Petroleum Training Standards Board should establish formal requirements and guidelines for these processes, in consultation with the industry and training institutions.

The primary objectives of safety training are to prevent the development of emergencies and to ensure a resilient capacity to meet the unexpected. Significant aspects of some emergencies can be simulated away from the site for purposes of training. Current basic offshore training includes the simulation in a water tank of the procedures that must be followed to escape from a helicopter overturned in the sea. Although the industry has been backward in developing simulators analagous to aircraft simulators, these devices are coming into use and deserve more widespread attention. Persons who, for example, have the responsibility for ballast control or for



6.4 The helicopter underwater escape trainer is a simulator used to provide realistic training in escape from a crashed or ditched helicopter that has overturned in the water.

well control should have experience during training in dealing with simulated faults unexpectedly introduced.

Since major emergencies may entail serious structural damage, personal injury and rig evacuation in highly hostile seas, the reality of these events cannot be simulated on-site. Nevertheless, there is a long tradition at sea of emergency drills, of mustering of fire control teams, damage control teams, man-overboard teams, and all-hands-to-lifeboat-stations. There are opportunities, however, for innovation in devising on-site simulation procedures for emergencies, for practising teamwork and for team criticism of actions decided on in these situations. These simulations can represent some features of fire and other damage at various locations on the rig, of communications failure, and of loss of team members through casualties. The objective of training by simulation, whether it be on-site or off-site, is to develop instinctive responses to the unexpected.

The major shortcoming of training for safety in the East Coast offshore has been the absence of clear standards and a clear definition of the roles and responsibilities of government and industry. The importance of training both for safety and for efficiency is recognized by all concerned; its present weaknesses are diagnosed; its future course mapped out. There is now a need for competent, concerted action to resolve the deficiencies, to clarify the standards and to ensure that those engaged in oil and gas endeavours off our shores are trained to work effectively, responsibly and safely.

7

HEALTH

CHAPTER SEVEN HEALTH

The essential objectives of an occupational health and safety program are to take precautions against hazardous events and to reduce the consequences of any accidents that do occur. As in all industrial operations where heavy equipment is handled, accidents occur during offshore drilling, resulting in injuries ranging from the severe, requiring evacuation of the patient to a hospital where specialized medical facilities are available, to the relatively minor which can be treated at the site in the sick bay by the rig's medic. An example of a hazard peculiar to the petroleum industry is loss of well control which can result in the escape from the well of toxic gases or of hydrocarbons in gaseous or liquid form, with the attendant risk of fire and explosion. The hazards associated with exploratory drilling are compounded in the Northwest Atlantic by a particularly hostile marine environment. There is potential for man-overboard incidents that may result in near-drowning or hypothermia, of accidents during the course of diving operations, which may require special hyperbaric facilities and medical expertise and of accidents during the handling of heavy equipment associated with the movement of the rig induced by wind and waves.

The avoidance of potentially hazardous events and of consequent injuries in offshore drilling operations may be achieved by maintaining safe conditions at the workplace, by following proper procedures whether on the drill floor or in the galley, and by preserving a high standard of general housekeeping on the drilling rig as a whole. The objectives of this process, however, require the constant vigilance and commitment to safety of every individual crew member; those responsible for occupational health, from the rig medic to the medical director of the operator, should, from their knowledge and experience, be given the opportunity to contribute.

Records of illness and injury provide important data for assessing the quality of health care offshore and for monitoring the development of any occupation-related illnesses. Individual medical records containing the pre-employment medical examination and the medical history of each worker are necessary also for determining the health status of persons while working on the rig. A well-maintained, confidential medical record system is essential to assessing the nature and origin of health problems that arise during employment. It can also, in time, make an important contribution to a better understanding of the particular health problems of offshore workers and lead to the adoption of preventive measures and thus to the improvement of health care in the offshore drilling industry. The extent to which offshore drilling operations are more hazardous to health than similar industrial activities on land can only be judged in relation to the nature of the activities, to the groups of employees at risk, to the types of injuries encountered and to the nature of the illnesses that arise both during and after employment. Current methods of collecting information on illnesses and on accidents during offshore employment are not sufficiently sys-

tematic, either nationally or internationally, to provide reliable data for comparable degrees of risk.[1] Attempts to estimate health hazards in the offshore drilling industry in Norway, the United Kingdom and the United States indicate, without exception, the unsatisfactory nature of the data available.[2] Where health data have already been collected for the population as a whole as in Medicare records, the Canada Health Survey, and on death certificates, the occupation of the individual has not, in many cases, been recorded, so that these data are rendered useless for analysing occupational hazards. Canadian regulatory authorities, in consultation with the industry and with physicians, should institute a system of collating and analysing data and of disseminating the results in a suitable form to all interested agencies.

Variations in the diagnostic criteria used by different rig medics in keeping their daily logs diminish the overall consistency of the data currently recorded on offshore rigs. The standard criterion for rating the severity of an illness or injury is time off work. Some unreliability in data can be ascribed to inaccuracies arising from time lost by a worker due, for example, to difficulty in obtaining transportation back to the rig rather than to the consequences of an illness or injury. The lack of reliability is greatest where there are marked differences among reporting agencies in the accepted standards for severity of illness or injury. This is due in part to inconsistencies in the terms used.[3]

Section 179(1) "Every operator shall, during a drilling program, prepare and submit to the Chief once each week. . .a report in respect of every accident that occurred during the preceding week and that involved an injury to or the death of any person."

Canada Oil and Gas Drilling Regulations. November 1980

The reporting of injuries arising from accidents poses some special problems. Accident reports are an accepted means of monitoring safety procedures and are one measure of the success of safety programs. Safety bonus schemes, pride in a safety record, an individual's embarrassment, reluctance to admit error or to ascribe blame to a colleague can all provide reasons for under-reporting accidents or near-accidents and for individuals not seeking medical attention for what is considered to be a minor injury. There is also a further possibility of inaccurate or incomplete data being provided because the rig medic does not understand the purpose for which the information is required. Nevertheless, even with the errors and inconsistencies that exist, this information would be useful to physicians and planners, if it were available in some processed form. The quality of the statistics would improve rapidly, however, with the adoption of consistent criteria for reporting an agreed range of data on a regular basis.

The first stage in the compilation of health data is the pre-employment medical examination. That examination establishes an applicant's health status before hiring. It assesses the individual's fitness, not only to perform a particular job, but also to live and work on the rig under routine conditions; it also assesses that person's ability to cope with an emergency without becoming a liability to himself and to others. The primary purpose of pre-employment medical examinations is to prevent individuals with conditions that present a health risk from entering offshore employment. The exclusion of people whose health makes them unsuitable for working offshore also minimizes the requirements for emergency medical care and potential risks to others on the rig.

It is generally agreed that high standards of medical fitness should be applied to offshore workers because of the nature and location of the work. But in the eastern Canadian offshore industry, pre-employment medical examinations are not

[1]The American Petroleum Institute initiated a recent study of morbidity and mortality involving fifteen thousand employees from nineteen companies. This large-scale study could have produced valuable findings on health hazards in the industry, but it failed to do so because there were too many differences in the ways in which data were collected to permit reliable conclusions to be reached.

[2]The sources now available for the compilation of a health data bank for the eastern Canadian offshore include accident reports to various public agencies and the daily logs kept by rig medics. Regulations require the operators to file reports for accidents which involve serious personal injury. Subsequent guidelines define lost-time accidents as injuries which prevent the worker from completing the present shift and the next regularly scheduled shift. The data collected is not subjected to a formal system of analysis.

[3]The International Labour Organization has called for a special glossary of terms to meet this need.

7.1 A thorough pre-employment medical examination is needed to establish the health status of applicants and to assess their fitness for offshore work.

standardized. The medical director of each operating company can have examinations conducted, using criteria and procedures that differ from those used by other companies. Drilling contractors and service contractors may also undertake medical screening of their employees in accordance with their own procedures. Basic minimum standards that cover the full range of diseases and disorders have been developed in the United Kingdom and in Norway. These criteria could form the basis for the establishment of minimum standards in pre-employment medical examinations for the eastern Canadian offshore industry, to be applied uniformly to all offshore workers irrespective of their employer. Appropriate standards should be arrived at and adopted following consultation among Canadian regulatory authorities, the industry and physicians involved in the provision of health care offshore. The responsibility for deciding fitness for employment must continue to rest, nevertheless, with the physician designated by the operator who needs to have a knowledge of the working environment and, in the case of diving activities, specialized medical training for which standards should be established. The examining physician can be expected, as in other areas, to exercise clinical judgment. Any departure from the minimum established criteria should be documented in the physician's report.

The effectiveness of any health care facility is generally judged in terms of: its adequacy to deal with the needs of the population that it is intended to serve; the provision of qualified personnel to meet these needs; the physical resources available to house patients and to carry out investigative and treatment procedures; and the extent to which existing services are being properly used and new services developed. The relatively brief experience and sparse data relating to offshore operations make it difficult to evaluate an offshore health facility. It should be evaluated on the basis of its adequacy to deal with everyday problems and to meet the demands of an emergency. The population is relatively homogenous, consisting mainly of young adults already medically screened. Minimum facilities, such as those normally found in a typical family practice clinic ashore, may be deemed sufficient for routine care, but not for emergencies offshore. A rig sick bay may, in adverse conditions, have to treat seriously ill or injured patients until they can be evacuated. The range of response in an emergency must be capable of rapid expansion for brief periods to care for many patients and to deal with major illnesses, such as trauma, burns, hypothermia and

7.2 The initial action of the medic, in the event of a serious injury on board the rig, is to stabilize the patient in preparation for evacuation to shore. If the patient cannot be evacuated immediately, further treatment may be administered under the direction of a shore-based physician.

other difficult medical problems. Adequate basic standards should therefore be established for these facilities.

It is hard to estimate the level of demand for medical service in an emergency. Serious injuries may result from an explosion, a fire, or a helicopter crash on or near the rig. Supplies and equipment should be kept for these emergencies to be used by the rig medic under the direction of the physician on shore. The medic and the physician on shore could then work together on the basis of known resources available on board the rig. The shore-based Medical Emergency Response Team would also know exactly what equipment and supplies they can expect to find on arrival.[4] The medical supplies and equipment that are held on each drilling rig are, at present, matters of individual company or Flag State policy. Minimum levels of medical supplies for the Canadian offshore should be established as standards following consultation between the regulatory authority, the industry, and the physicians.

The Canadian regime for the provision of health care services to offshore drilling operations is more complex than that of Norway, the United Kingdom and the United States because of the division of powers under the Canadian Constitution and the number of agencies involved. Under the Canadian Constitution, responsibility for health and occupational safety within provincial boundaries rests with the provincial ministers of Health and of Labour. Because of the lack of Canadian regulations and the use of rigs of foreign registry, matters relating to occupational health and safety in the eastern Canadian offshore drilling industry are currently governed by the standards of other states. The result is a multiplicity of standards, the acceptance of which on an *ad hoc* basis by Canadian regulatory authorities complicates contingency planning and quality control. This problem would disappear if all drilling operations in eastern Canadian waters were governed by Canadian laws, codes and practices with respect to occupational health and safety. The extension of provincial health jurisdiction to the offshore would also resolve many of the present inconsistencies in the licensing, registration, training, and continuing education of those health professionals who are engaged in the offshore drilling industry.

[4]In St. John's, Newfoundland the Medical Emergency Response Team is made up of specialist physicians, nurses and respiratory technicians from the Health Sciences Centre who may be flown to any location to administer medical care. A similar service has not, so far, been formalized in Nova Scotia.

It is therefore necessary that there be provided a mechanism for effective co-operation and collaboration among the various federal and provincial agencies responsible for health and occupational safety in offshore drilling operations. That mechanism should provide for the views of physicians with experience in offshore health care, professional representatives of the Departments of Health and of Labour from both levels of government, medical and safety professional representatives from the offshore industry, and offshore workers whose welfare is at stake.

Current federal regulations require that the operating company holding a permit from the Canadian regulatory authority be responsible for all health matters in respect of its operations. Adequate standards for the provision of health care offshore have not been established. In practice there is a significant variation in the standards, from excellent on some rigs to inadequate on others. This responsibility for all health matters should be reflected in organizational terms, so that clear lines of authority and communication are established to improve efficiency under normal conditions and to avoid confusion in emergencies. The operator's medical director should be responsible and accountable for all aspects of health care, including pre-employment medical examinations of all personnel, for the professional competence of the rig medic, for the relationship with supporting medical services on shore and for determining clearly the health care arrangements for all personnel on board the drilling rig in normal and emergency conditions.

The rig medic who is responsible for providing medical services and the supervising physician on shore must both have a wide range of skills. Although some physicians have been employed on rigs on a temporary basis, the medical duties at the routine level do not normally require or justify a physician's skills and training unless the rig is located in a very isolated area, as for example, the Labrador Sea. The more appropriate alternative is a registered nurse, preferably with experience and training in outpost and offshore practice. Medics retired from the armed forces, emergency technicians and registered nurses have all been employed as rig medics. Medics trained by the Canadian Armed Forces for independent duties (classified TQ6B), particularly those who have had independent sea-going experience, appear to have an appropriate background for rig medic duties. They, however, have at present no recognized status, legal or professional, in the civilian health care system, with consequent medico-legal implications in determining professional liability. Action should be taken to remove this handicap. The qualifications and experience of emergency technicians are considered unsuitable for the rig medic position. Registered nurses have the minimum requisite skills, the legal and professional status and recognition in the health care system, but additional training in selected areas is necessary.

An advanced first-aid team should be formed and trained to assist the rig medic who may be faced, in an emergency, with caring for an acutely ill patient or for a number of casualties. The training of team members should include components from the Canadian Heart Association's syllabus on cardiopulmonary resuscitation (CPR) and from the petroleum industry's approved course on hydrogen sulphide poisoning.[5] Regular drills and refresher training should be provided by the rig medic for all members of advanced first-aid teams. Since supply vessels do not carry medics, one or two members of their crew should receive advanced first-aid training in addition to the elementary training received by all crew members.

The designated physician on shore who supervises the rig medic should be specially trained. This training should consist of instruction in emergency medicine including basic life support, and the management and treatment of cardiac arrest, near drowning, and hypothermia. A basic knowledge of diving medicine should also

[5]It should also cover such medical procedures used in the treatment of patients as control of hemorrhage or management of intravenous infusion to meet the standards laid down by the Canadian Medical Association for Emergency Medical Attendants.

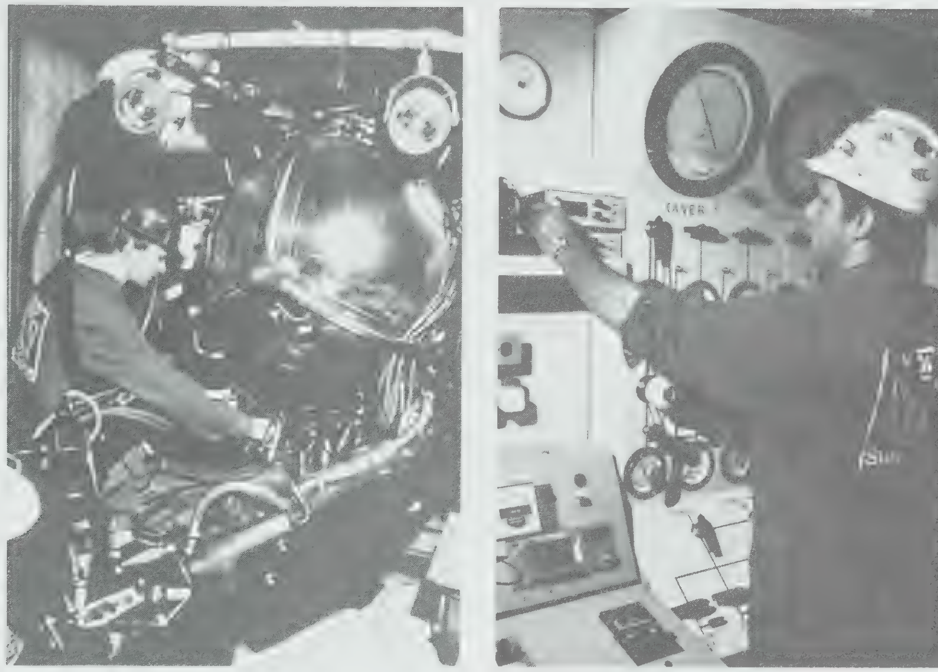
be required. After this initial training, the physician should receive continuing education on methods and techniques in such areas as hyperbaric medicine, the management of trauma and rescue procedures. In addition to the necessary clinical skills, the physician on shore should have knowledge of the administrative procedures within the operator's organization and of action to be taken in an emergency in accordance with the operator's contingency plan.

Diving presents a special challenge to the offshore health care system. There are two methods of performing underwater operations involving divers. The better choice in terms of safety are the one-atmosphere diving systems (ADS). These devices have in general a good safety record although they are vulnerable to entrapment and care must be taken to ensure that life support can be sustained for as long as it takes to rescue divers who are trapped. Although remotely operated vehicles (ROVs) and ADS are used extensively in offshore diving operations, there remain some underwater operations requiring fine hand and eye co-ordination, manual dexterity, versatility or work in confined spaces which must be performed by divers at ambient pressure.

It appears that the health and safety aspects of diving operations carried out in connection with offshore drilling operations in eastern Canadian waters have been generally satisfactory. Regulations do not, however, address surface decompression diving nor deal adequately with the important matter of the training of diver medical technicians. Although diving can be carried out from any type of vessel or platform, contemporary diving support vessels are primarily dynamically positioned. As a number of accidents have occurred during diving operations from dynamically positioned vessels, this mode of diving should be the subject of ongoing scrutiny by Canadian regulatory authorities. A problem area is the evacuation of divers from an offshore location. A diver, while still in saturation, may become ill or be injured and have to be stabilized in the pressure chamber on board the rig before being transferred to shore. A number of divers may have to be transferred to shore while still in saturation, if a general emergency requires the evacuation of the rig while diving operations are in progress. There is need for hyperbaric chambers which can transport divers to a shore-based recompression facility and for compatible hyperbaric facilities on shore in St. John's as in Halifax.

All divers need to be trained to a high standard of first aid, including training for diving emergencies. Providing health care to the sick or injured diver presents special problems because of the isolation of divers in saturation or deep, mixed-gas diving. Since neither the rig medic nor the diving superintendent can attend the diver in the chamber, diving teams should include a diver medical technician trained to render immediate medical care. There are, at present, no courses available in Canada for diver medical technicians and persons functioning in this role have to be trained abroad. For the diver medical technician, additional course modules would be required on near-drowning, hypothermia and on topics and procedures specific to diving medicine. Physicians must not only be specially trained to conduct medical examinations for fitness to dive, but some should be trained as specialists in diving medicine.

The operator is responsible for the health and safety of all personnel engaged in the operation, including divers. The operator's medical director should therefore have access to persons qualified to assess safety in diving and to provide medical backup and services when diving operations are in progress. There is need for further research to be carried out in Canada on the physiological aspects of diving in cold ocean conditions and on the development of diving equipment that is specially adapted to the Canadian offshore environment. In specific terms, improved "bail-out" gas supply systems for deep diving ought to be developed and further research should be undertaken on the physiology and pathophysiology of decompression sickness, thermal protection and oxygen toxicity.



7.3 Diving operations present unique problems for routine and emergency health care offshore. Although manned submersibles operate at atmospheric pressure, many underwater activities still require that divers work at ambient pressure and undergo slow decompression to avoid decompression sickness.

Planning for emergencies must provide for a wide range of support facilities, both offshore and on shore, for several phases of intervention from immediate first aid rendered to the patient by the rig medic through consultation with the physician on shore to the decision to evacuate the patient from the drilling unit or supply vessel. The medical emergency plan should provide for efficient transportation arrangements on shore following evacuation and for reception of patients by appropriate hospital specialist units.

Further research and development are needed to improve methods of communication in the field of health care for offshore operations and to improve the quality of the response in emergencies and for routine consultations. Advances have been made in telemedicine through the transmission of medical data such as x-rays and electrocardiographs, which are beginning to enhance the consultative process between rig medic and onshore physician. With respect to the offshore working environment in general, more biomedical research is required in a number of areas such as hypothermia and seasickness which are routinely experienced during marine emergencies. An intensification of basic research in these areas would provide greater knowledge of the physiological and pathological processes involved. This in turn would give a more rational base for prevention and treatment.

Severe winter storms, blowouts, explosions, collisions or fire may create a disaster. Canadian regulatory authorities require that each operator with drilling operations in eastern Canadian waters prepare and submit for approval a contingency plan which describes in detail the response to an emergency, the responsibilities of key personnel with respect to medical matters and the roles and responsibilities of the rig medic and of the consulting physician. There is need for regional plans to activate and co-ordinate hospital and medical resources in the event of a major disaster. When a disaster has been declared, joint action will be required to mobilize quickly all the resources of industry, government agencies and health care facilities on shore. The response that each will make must then be integrated into a disaster plan for the area or region and be tested periodically in a full-scale exercise. The medical aspects of contingency and disaster plans need to be evaluated on a regular basis.

8

ESCAPE AND SURVIVAL

CHAPTER EIGHT ESCAPE AND SURVIVAL

In 1926 the Northwest Atlantic experienced what meteorologists called the worst winter in 100 years. A 21-day hurricane in October was succeeded in late January by a winter storm of almost unprecedented destructive force. The storm raged relentlessly for more than a week. Seven ships went down, and many lives were lost. Among those rescued were the twenty-five crewmen of the British freighter *Antinoe*. The freighter had been swamped and drifting for sixteen hours with no indication of her bearings when the American luxury liner *S.S. President Roosevelt* picked up her distress signal and managed to locate the stricken vessel. The waves broke portlights in the *Roosevelt's* midships cabins 70 feet above the sea and the liner pitched 30 degrees in the troughs. The winds were measured at 70 knots with gusts to 150 knots. Lifeboats were launched down the 60-foot drop to the sea, only to capsize, spilling the oarsmen into the icy water. Finally, after 100 hours of uninterrupted rescue attempts, the almost lifeless seamen were plucked from the sinking *Antinoe*, and hoisted aboard the *Roosevelt*, "Frost-bitten, thinned in blood, gnarled to the bone / But everyone surviving."[1]

This rescue was not extraordinary; records of similar feats abound in North Atlantic ports. For centuries, society has employed lifeboats to secure the protection of those of its members who, whether for transport, pleasure, profit or duty, have ventured out to sea. During that time, most of the marvels of our modern technological world have come into being, and the contrast between then and now in methods of travel, communication, medicine, and industrial endeavour is truly remarkable. In some areas progress has been slower, reflecting a shift in society's priorities. As man developed faster and safer ways of traversing the ocean, the passenger vessel has come to play a reduced role and little attention has been paid to the development of marine evacuation systems.

But there has been one change in the marine milieu – a dramatic, new addition to the fleet of vehicles used to ply or harvest the seas. Many maritime locations throughout the world, including some of the harshest in terms of climate, are being exploited by ocean-going drilling rigs, designed and instrumented at the "leading edge" of technology. These sea-based marvels of industrial progress house up to a hundred workers who are exposed to all the traditional environmental foes of the mariner in addition to new dangers arising from the rig's industrial mission. And yet, and herein lies the paradox, alongside the sophisticated system of machinery and equipment to drill the well is the anachronistic system of lifeboats and life rafts to protect the workers. Admittedly the traditional wooden lifeboats have been replaced by those of fibreglass-reinforced plastic; they have been enclosed, fitted with motors,

[1]Details from historical accounts of the disaster; quote from E.J. Pratt's "The *Roosevelt* and the *Antinoe*".

sprinkler systems and communication equipment. But the same hazards presented by lifeboats half a century ago exist today; they still cannot be launched safely into high seas without fear of a malfunction of the launching or release mechanism, or of being blown or washed back against the structure from which they are launched. To state that they fall far short of serving their purpose of protecting the workers is to restate the conclusion reached by virtually every study prepared by research institutes, government or industry on this subject; by experts who have spoken or written on offshore evacuation systems; and by inquiries into the various marine disasters that have claimed the lives of hundreds of people in recent years.

There is, at present, no proven system for the evacuation of offshore drilling rigs that can assure a reasonable chance of survival to those who are obliged to use it during severe storms and other environmental hazards. More specifically, there is no existing evacuation system which is adequate for the environmental conditions frequently encountered in the drilling areas off the eastern coast of Canada.

The astonishing lack of technological progress in evacuation systems for offshore rigs over the years is sometimes rationalized on the grounds that the standard evacuation device for drilling rigs today is the helicopter. Yet those who have studied offshore safety in the North Sea estimate that an installation will have to be evacuated by some means other than helicopter – this normally means by lifeboat – at least once during its operational life of 20 years.[2] Estimates for offshore eastern Canada would probably be higher because helicopter rescue is more uncertain; the rigs are working farther from the land and therefore from the helicopters' base, and at certain times of the year there is a greater likelihood of rime icing or fog to prevent flights. These estimates have in actual fact proved conservative. There have been three emergency evacuations of drilling rigs by lifeboat off Canada's East Coast since 1982. In the first, no lives were saved; in the second, only one life was lost; in the third, all survived. A major factor influencing these outcomes was weather; two occurred in calm seas; one during a winter storm. Yet the circumstances on the night of the *Ocean Ranger* disaster were less adverse than those surrounding many successful vessel evacuations off our shores; the exact location of the rig was known; supply vessels and search and rescue helicopters were on stand-by duty, and the rig itself was equipped with modern evacuation systems. Why an effective rescue was not achieved has provided industry and government with serious food for thought. Improvements must be made in the technology, the equipment and the management of offshore emergency evacuations. Long-term research and development must be started now, but until they come to fruition, short-term interim measures must be taken to upgrade existing evacuation systems.

It is generally agreed that, under normal circumstances, the safest haven offshore is the drilling rig itself. Nevertheless, abnormal circumstances can and do arise. Approaching ice, storm conditions, structural damage, loss of stability, fire, blowout, or the escape of toxic gases from the well – any one of these conditions can make getting off the rig a prerequisite to survival. Evacuation may also be needed from a supply vessel in distress or from a downed helicopter. Those controlling offshore oil exploration recognize the inadequacy of present marine escape and survival technology, particularly during storm conditions. The first line of defence in this potentially perilous situation has been to reduce the need for evacuation by enhancing the safety both of the rig itself and of its support operations. The second has been to determine when evacuation may be required in sufficient time to choose the safest method. When time and weather permit, a rig will be evacuated by helicopter; if that is not possible, the options narrow rapidly through dry transfer to a standby vessel by crane and basket, to the conventional fallbacks of escape by lifeboat and life raft,

[2]Study for the U.K. Department of Energy and the U.K. Offshore Operators Association, 1983. For this study a successful evacuation was defined as one which restored personnel to a level of risk no higher than that which pertained before the emergency occurred.

8.1 The evacuation of a rig by helicopter may be constrained by adverse weather, an inclination of the drilling rig or the presence of toxic or combustible gas. The time required to muster a crew and fly to the site, and the limited capacity of each helicopter impose further limitations.

and finally, directly into the sea. A supply vessel will be evacuated by davit-launched lifeboats and the occupants of a downed helicopter will normally board inflatable life rafts directly from the sea. The effectiveness of each of these methods is seriously restricted by present design and operational limitations; few are completely reliable even under favourable environmental conditions and many pose severe problems in fog, storms or rough seas.

Although helicopters are generally considered to be the safest method of evacuating offshore drilling rigs, there is limited benefit in a safe option if that option is only viable when weather and time permit its use. The extent to which weather impinges upon the operations of helicopters varies with the type of machine, but most of those servicing rigs off Canada's East Coast are affected by poor visibility, and none is capable of start-up in high winds or of flying when icing is a threat. Fog, blowing snow, freezing rain, and high winds are characteristic of that offshore area and these conditions may, either singly or in combination, prohibit helicopter flights as much as one-third of the time. While pilots may well exceed "normal" operational limitations during an emergency, there have been, and there will be, many instances when helicopters simply cannot fly and other means of evacuation must then be sought. If an evacuation occurs because of a blowout, fire, or severe list, helicopters may not be able to land on the rig, and if an emergency arises with little warning, helicopters will not have time to reach the rig before evacuation becomes necessary. If advance warning is given, the helicopter's distance from the site, its carrying capacity, and the proximity of other rigs for offloading passengers and for refuelling all remain critical factors. The net result of these conditions is that there is a relatively small percentage of offshore emergencies in which helicopters will be able to evacuate rigs. Some studies predict that helicopters will be available in only one out of ten events; more optimistic estimates are for one out of four.

Many of the problems that limit the use of helicopters to evacuate rigs are, at present, insoluble for either technological or practical reasons. Helicopters with longer range, anti-icing capability, and better automatic flight control equipment for night and low visibility flying are being developed and should be used as they become available. The time required to reach a rig site and remove a large number of crew members may be shortened somewhat by helicopters with higher speed or greater payload, but unless a helicopter is to be stationed at each rig location and reserved

for possible evacuations, a practice that is not deemed to be feasible during the exploration phase, there is no practical way of assuring that helicopter evacuation services will be available on short notice offshore eastern Canada.

Helicopter flights, whether rescue or routine, are of course subject to inherent risks arising from weather, mechanical problems or pilot error. The risk of a helicopter crash is small, but small, too, are the passengers' chances of survival. Ditching or controlled landing at sea offers a reasonable chance of survival; a Sikorsky S-61, for example, was successfully evacuated after ditching off the coast of Nova Scotia in March, 1985. Incidents in other regions have ended less successfully; the 17 helicopter accidents in the North Sea between 1969 and 1982 involved 157 persons and resulted in 61 fatalities.[3] Escape from a downed helicopter is complicated by the fact that, although most helicopters offer some form of built-in or appended buoyancy, many of these top-heavy craft capsize as they land in rough water. Survivors have, on the average, three minutes to escape from an overturned helicopter and they are then confronted with the task of boarding inflatable life rafts. There are indications that the chances of survival of those involved in a crash or ditching are increased by helicopter underwater escape training (HUET), but improvements in the design of helicopters that operate routinely over water are also needed. Engineering research aimed at increasing the buoyancy and stability of a downed helicopter is to be encouraged. So too are radically new helicopter designs paralleling the dramatic improvements made in other branches of the aviation and aerospace industries.

A second evacuation method is dry transfer – the movement of people from a rig or vessel in distress directly onto another vessel without bringing them into contact with the water. The only method of dry transfer used off the East Coast of Canada is the rig's personnel basket which is lowered by conventional crane to the deck of a standby vessel. Because of the relative motions of the drilling rig and the standby vessel, this mode of transfer involves some risk, particularly in high seas, and is not permitted in the North Sea except in emergencies. If the rig has lost power, electric cranes cannot operate, and dry transfer is no longer an option. This circumstance forced the crew of the *Vinland* to abandon plans for a dry transfer and evacuate the rig by lifeboat after a blowout off the coast of Nova Scotia in February, 1984. Diesel cranes may also present problems if there are combustible gases in the area of operation.

Several systems are under development to improve dry transfer from the rig to the standby vessel. Sliding chutes and telescoping gangways are, at present, subject to weather and sea-state limitations which prevent their use off the East Coast of Canada, but their capabilities may be extended as a result of further research and development. Sophisticated dry transfer systems which propel capsules along wires, cable-car fashion, to dedicated receiving vessels are also being developed, but the expense involved in maintaining a high-technology receiving vessel in a standby position at each rig location may well make their use prohibitive, unless a number of exploration or production facilities are grouped together.

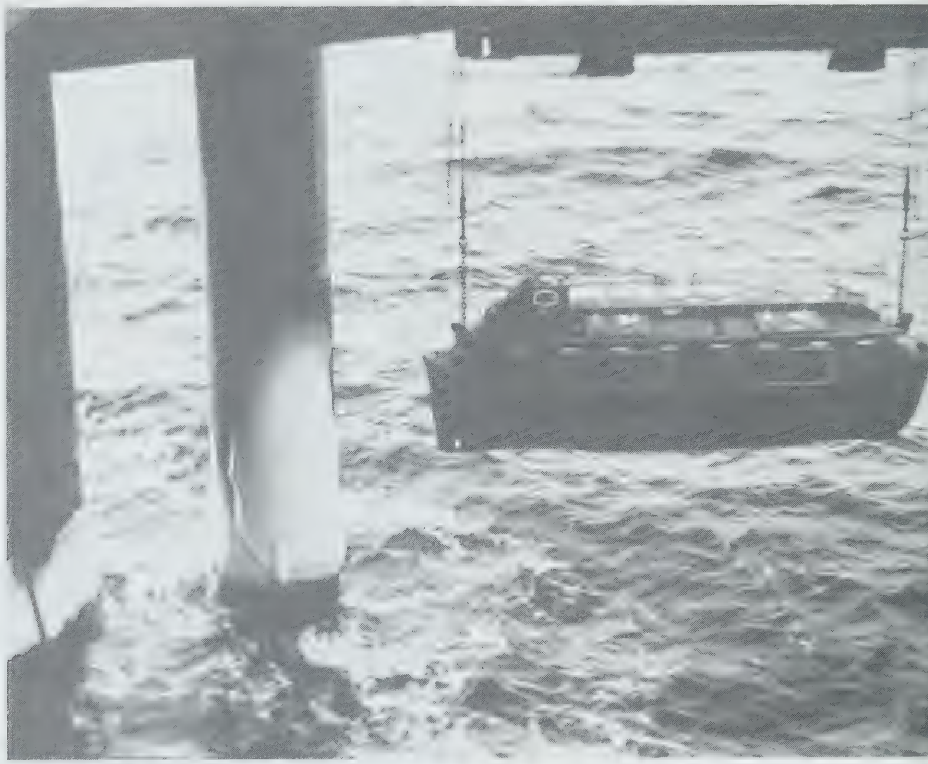
When an emergency occurs and time, weather or circumstances preclude evacuation by helicopter or dry transfer, those on offshore drilling rigs must rely on lifeboats. While size, shape and positioning of lifeboats will vary from rig to rig, they must, by Canadian regulation, have the capacity and potential to provide a means of escape for at least 200 percent of the crew and must be positioned in two different locations on the rig. Generally made of fibreglass-reinforced plastic, these totally enclosed motor propelled survival craft (TEMPSC) are designed to be fire retardant and wave resistant, but recent experience has raised questions about the adequacy of existing standards for the storm-ridden and ice-frequented waters of the Northwest Atlantic.

[3]U.K. Civil Aviation Authority Safety Data and Analysis Unit.

8.2 Dry transfer with personnel baskets is often used to move crew members between rigs and supply vessels. This operation becomes increasingly dangerous as sea conditions worsen.

During the public hearings into the loss of the *Ocean Ranger*, evidence was received that the sprayed chopped fibreglass construction often used for lifeboat hulls was contrary to the primary construction specifications of the United States Coast Guard and was permitted only upon demonstration that it would be the equivalent of the required woven roving method. There is little, if any, testing of the actual hulls of lifeboats. The tests are, in fact, carried out on sample pieces of the fibreglass specially fabricated by the lifeboat manufacturer for that purpose. There is not sufficient assurance that the lifeboat hull as a whole will have the same characteristics, a fact which illustrates the need for an effective quality control system. In response to these concerns, existing structural requirements for lifeboats should be re-assessed and more stringent impact standards established.

Another feature of the TEMPSC which has proven inadequate is the arrangement for restraining passengers. The forces to which the occupants may be subjected during lowering and release are dangerously high, and passengers are not adequately protected by the seats and the seatbelts in most current davit-launched models. Tests of current lifeboat designs, conducted at a drop height of 10 feet, showed that peak forces could easily reach 20 times the force of gravity. Figure 8.4 shows the deceleration range that is acceptable for a human passenger, seated in a conforming cushioned seat and restrained by both lap and shoulder harnesses. Without these restraints, serious injury is likely to occur, even at much lower decelerations. These restraints should be required, even though they may reduce the passenger capacity of existing boats by 15 to 20 percent and consequently necessitate the provision of additional ones.



8.3 A conventional, double-fall TEMPSC being lowered into a relatively calm sea. The wire extending from the helmsman's tower at the stern connects to the brake on the davit above, and allows the rate of descent to be controlled from within the lifeboat.

The traditional hazards of launching lifeboats are increased on drilling rigs because of the high freeboards; on the *Ocean Ranger*, for example, the lifeboats were from 70 to 128 feet above the water, according to the rig's draft. Because neither semisubmersibles nor jack-ups are structures that can provide a lee, lifeboats are subjected to the full force of wind and waves during launching. The risk of a lifeboat being blown forcibly against the structure by wind or swept against it by waves is therefore high, and launching problems have proven fatal in several recent rig casualties. In the *Alexander L. Kielland* disaster, only five of the seven lifeboats were launched and none without mishap. A launching mishap took the lives of 36 crew members during an emergency evacuation of the *Anchova* platform off the coast of Brazil in August, 1984. In the *Ocean Ranger* casualty, while the evidence is not clear regarding how many of the three available lifeboats were actually launched, it is clear that none reached the water without serious damage. Current craft are considered unlikely to be launched safely into wave heights over eight metres and wind speeds over 50 knots.[4] The frequency of conditions exceeding these limits off the East Coast of Canada during the months of December to March varies from about 25 percent to 45 percent of the time.

The most hazardous aspect of launching the lifeboat has long been and continues to be the way the craft is released from the falls. The circumstances that lead to the launching of a lifeboat in an emergency are often not conducive to careful, measured action by those involved. People will generally be frightened, sometimes panic-stricken and occasionally injured. It is therefore essential that the release mechanism be as simple as possible, requiring a minimum number of actions and that members of the crew be trained in the launching sequence until they can perform the actions instinctively. It is also essential that there be little or no possibility of misoperation or mechanical malfunction of either manual or automated release systems. A striking

[4]Hollobone, Hibbert and Associates. *Assessment of the Means for Escape and Survival in Offshore Exploration Drilling Operations*. June, 1984.

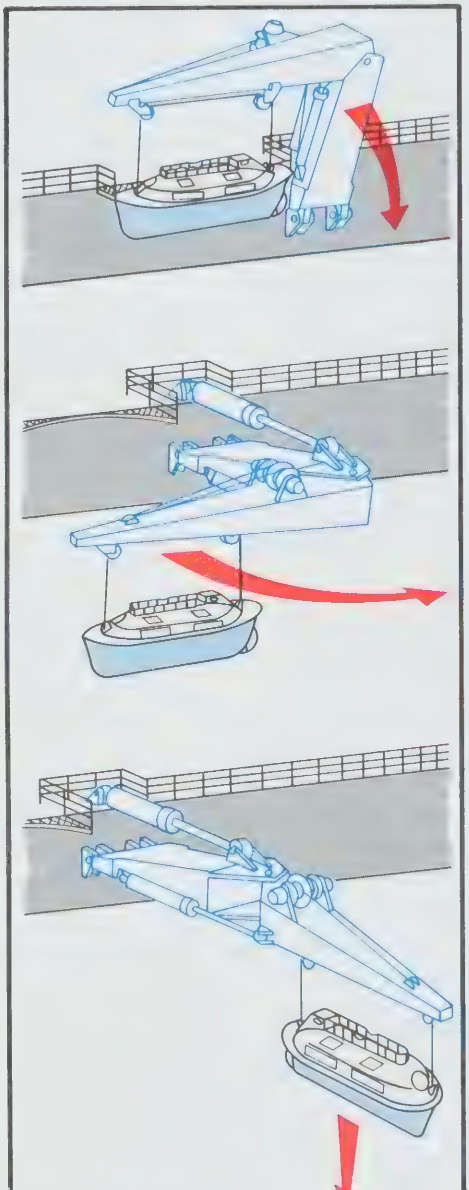
illustration of this point occurred when a North Sea platform was evacuated because of an explosion and fire in 1975. The platform was equipped with three 28-person emergency capsules and a conventional lifeboat. Two of the capsules were in the middle of the fire zone; the third was boarded by the first six crew members who reached it. They attempted to launch immediately, mishandled the release mechanism, and the capsule plunged into the sea, killing three of the occupants and seriously injuring the other three. The remaining 64 people evacuated the rig successfully in the conventional lifeboat even though it was designed to hold only 50 persons.

There are two main categories of release systems in current use. On-load devices permit the occupants of the lifeboat to release at any time including in mid-air; off-load mechanisms release the lifeboat automatically when it becomes waterborne, although there is generally a critical period between first contact with the crest of a wave and the point at which the craft is actually supported by the water. Many launching systems involve double or twin falls. In this case both falls must be released simultaneously; if one fails, as occurred during the *Alexander L. Kielland* evacuation, the boat is left suspended vertically from the other.

Although lifeboats may never provide an entirely reliable escape route from offshore rigs during stormy weather, improvements in launching methods are underway and are long overdue. The basic problems are ensuring that the lifeboat clears the rig's structure during lowering; that it is successfully released; and that it escapes from the vicinity of the rig to the open sea before being forced back against the rig's structure by wind and waves. Although there is some disagreement on the issue, it is now generally considered advantageous to lower a lifeboat as quickly as possible to minimize the chances of impact, and then to release it a few feet above the water by means of an on-load release mechanism. Rapid lowering on winches followed by a short free fall would require several major design changes in the typical TEMPSC. These would include strengthening the basic structure, restraining the passengers to protect them from decelerations which could cause injury, and providing for automatic release at a predetermined height above the sea. Means must also be provided to trigger this automatic release and to reduce decelerations at the time of water impact. Devices have been developed to perform each of these functions, although testing has tended to be under ideal conditions.

Several new developments may provide alternative methods for launching lifeboats which are safer than the traditional davits and falls. The most significant appears to be the Norwegian free-fall lifeboat which has been tested successfully in nine-metre waves and which has recently been approved for use by Canadian authorities. The free-fall lifeboat in outward appearance is almost identical to the conventional TEMPSC. It is, however, of stronger construction and, although most are built of fibreglass-reinforced plastic, several firms are developing and testing steel and aluminum models. The free-fall lifeboat is stored perpendicular to the rig's perimeter and launched by being dropped either vertically, usually from a fixed platform, or along a short skid at about a 35 degree downward angle which propels the craft away from the rig after it enters the sea. Skid-launched boats have been tested successfully from a height of 20 metres and the vertically dropped steel model from 30 metres. The lifeboat is released from inside and falls free by gravity. The occupants are strapped firmly into padded conforming seats so that the deceleration forces on their bodies are evenly distributed when the boat hits the water.

Other improvements in lifeboat launching technology include articulated davits which extend the lifeboat outward from the platform and rotate it to a perpendicular position relative to the rig for lowering (Figure 8.5). Hydraulically controlled launching systems, for example, suspend the lifeboat from the top of a long beam which is hinged at its lower end to the structure of the rig (Figure 8.7). When the beam is activated for a launch, the weight of the lifeboat pulls it outward and away from the rig's structure; the boat is then launched by lowering it from davits but



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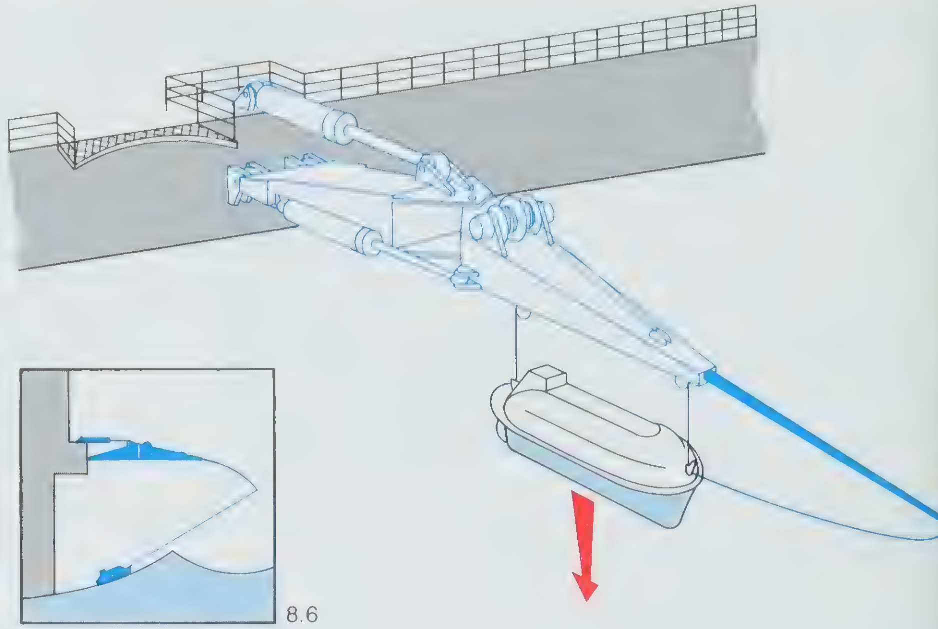

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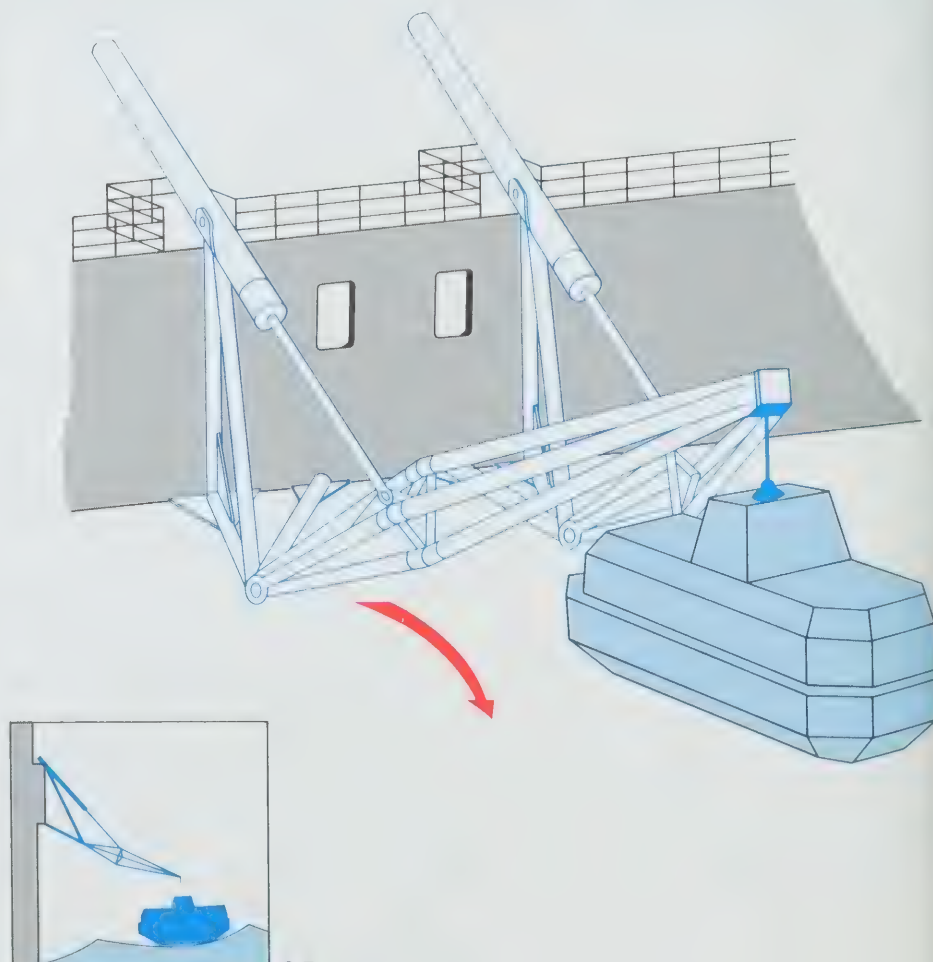

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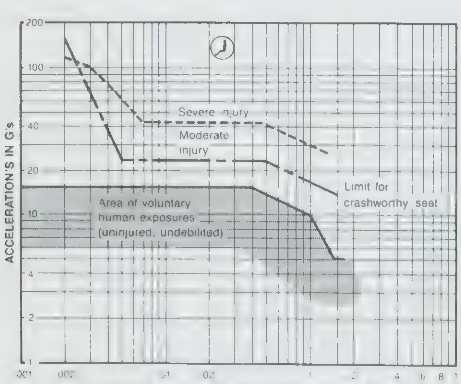


ACCELERATION'S IN G's
200
100
40
20
10
4
2
1
Severe injury
Moderate injury
Limit for crashworthy seat
Area of voluntary human exposures (uninjured, undebilited)
DURATION OF UNIFORM ACCELERATION SECONDS

8.4

8.4 The graph (lower left) shows the duration and magnitude of headward acceleration and the consequent effect on the occupants of the lifeboat. The graph was developed from specifications issued by the United States Air Force, and presumes padded, conforming seating and a four-point restraint harness.

8.5 The Debarkosafe articulated davit developed in Norway orients the TEMPSC perpendicular to the rig's perimeter and extends it beyond the structure to lessen the probability of impact.

8.6 The Watercraft PROD system, illustrated in conjunction with the articulated davit, guides the TEMPSC away from the structure after launching. The PROD system may also be used with a conventional davit to pull the TEMPSC into the perpendicular orientation during launching.

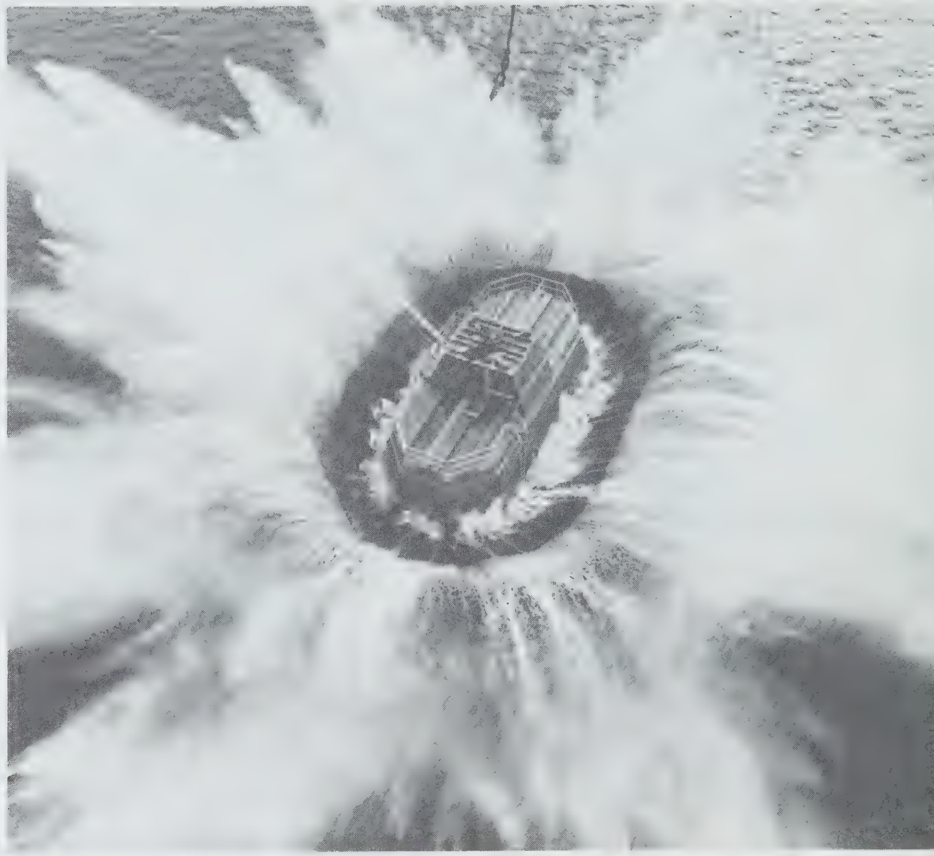
8.7 The launching system developed for the Götaverken Arendal/von Tell Nico Lifescape utilizes a pivoting A-frame beam lowered under hydraulic control. The Lifescape is extended approximately 8 to 12 metres from the rig, and is released to free fall from a height of approximately 8 metres.

from a level well below the rig deck. One recent use of this type of launching mechanism is the Lifescape system developed by Götaverken Arendal AB and von Tell Nicoverken AB. A capsule made of steel and capable of accommodating up to 125 people forms a safe haven on board the rig during an emergency and is released only as a last resort. The capsule is then lowered, extended and dropped a short distance into the sea. While the Lifescape offers considerable promise, it awaits regulatory approval and may not become commercially available for some time. The preferred orientation and displacement (PROD) system designed by Watercraft also rotates the lifeboat to point away from the rig in the course of the lowering process. One end of a tag-line is attached to the bow of the lifeboat and the other to a flexible boom which is fixed to the platform or to an articulated davit. This line keeps the lifeboat perpendicular to the rig's perimeter when it reaches the sea and pulls it away from the rig until the craft overshoots the flexible boom and the line is automatically released.

The practice of installing lifeboats perpendicular to the rig's perimeter has become more prevalent since the loss of the *Ocean Ranger*. This procedure ensures that the lifeboat will not have to turn under power in order to head away from the rig. Lifeboat engines are usually required to achieve at least six knots, the minimum speed needed to make headway in heavy seas. But more important than maintaining a certain speed while underway is the need for an initial acceleration that can take the lifeboat rapidly away from the rig. Existing lifeboat engines should be modified or replaced to meet this requirement.

Few of these innovations for improving lifeboat launching systems for offshore use have been tested in the storm conditions of the North Atlantic. Model tests for free-fall systems have been favourable, as have drops in calm, harbour waters, but these are not an adequate substitute for testing offshore under varying conditions. What is needed is a commitment by all those who will benefit from substantial improvements in escape systems, and a full field-testing program using an operating platform, a recovery vessel, lifeboats and instrumented manikins, all of which may be required for a considerable period of time. This process could well be combined with the existing operations of a drilling rig, so that neither the rig nor the recovery vessel is dedicated exclusively to the testing. But whatever the method, testing must be done, and new systems refined, approved and put into use before we are reminded, yet again, of how vulnerable are the means of escape now provided to those who work offshore on our behalf.

Once a lifeboat is successfully launched, the emphasis turns to its survival and recovery. Access to the TEMPSC is by the several hatchways on each side and one or more at the top, the size of a manhole, for emergency exit. Rescuing survivors from an enclosed lifeboat by helicopter hoist is generally considered too hazardous to attempt in all but exceptional circumstances. Recovery must therefore be by vessel but the transfer of survivors is always problematic. The exterior of the TEMPSC is difficult to walk on, particularly if it is iced, and the differences in size and motions between the lifeboat and the vessel makes the transfer in rough or even moderate seas highly dangerous for healthy survivors and virtually impossible for the injured. There have been several fatal incidents involving loaded lifeboats under tow. It is usually considered safest, therefore, to leave survivors in a TEMPSC under its own power, until the weather abates or a lee can be provided. In many areas off the East Coast of Canada, this delay may extend to many hours or even days. During the evacuation of the *Vinland*, the crew spent about eight hours in the lifeboats, until they reached the lee of Sable Island and could be transferred to supply vessels. The interior design and outfitting of the typical TEMPSC makes prolonged occupancy uncomfortable, debilitating and potentially dangerous. The seats are uncomfortable, heating and ventilation are poor, the interiors are noisy, communications and emergency system controls are often inaccessible and poorly designed for use by persons



8.8 The Lifescape, undergoing full-scale prototype free-fall testing. In order to protect the occupants from the effects of acceleration, the Lifescape incorporates padded, conforming seats and four-point restraint harnesses.

wearing abandonment suits, and there is inadequate provision for the seasick and the injured and none for stretcher cases.

Regulations governing drilling rigs require that life rafts be provided as an alternate means of evacuation to the TEMPSC. The traditional raft which is thrown overboard and inflated serves very little purpose on a high freeboard drilling rig; to expect the crew, particularly when clad in bulky abandonment suits, to climb down scramble nets, swim to the life raft and clamber aboard is not realistic. Recent regulations require that life rafts be davit-launched from rigs. They are inflated and boarded on the deck and launched from a davit or crane by a single wire. Though they are far superior to the throw-overboard type, these rafts are inferior to the TEMPSC as a means of evacuation. During the launching process, the raft is subject to the same forces of wind and wave as the lifeboat, but its lighter weight and construction give it less resistance. Because it has no means of propulsion, the direction of its travel cannot be controlled after release from the rig and there is high risk of wind and waves smashing it against the structure.

Life rafts also lack fire protection and are not as sturdy as TEMPSC. Although the evidence in the case of the life rafts from the *Ocean Ranger* is not conclusive, there are legitimate grounds for concern that a life raft, built to United States Coast Guard standards, is not sufficiently sturdy to survive a severe storm on the Canadian East Coast. Even though life rafts will remain as secondary evacuation systems for rigs, they are the only escape devices for downed helicopters. Improvements are needed both in the construction of life rafts and in the methods used for launching them from offshore structures. Water-filling keel pouches, which are readily available, would provide a major improvement in stability in storm seas; materials and methods of joining the fabric could be improved to strengthen the raft and maintain its structural integrity in storm conditions; and immediate consider-

8.9 Basic training in the use of abandonment suits and life rafts under realistic conditions is an important facet of emergency preparedness. Evacuation directly into the sea, however, is regarded as the least favourable of existing evacuation methods.

ation should be given to the use of fire and heat resistant materials in life raft construction. There should also be improvements in the means of boarding the raft from the sea as the agility of survivors in the water may be considerably constrained by abandonment suits, hypothermia, and exhaustion.

Abandonment suits and personal flotation devices or life jackets, in their present form, are not considered a means of escape from a drilling rig; rather they are used to extend survival time in the water or in a lifeboat or life raft until rescue arrives. The question of how long a person can survive in the waters off the East Coast of Canada is much debated, but the figure is probably several hours with an abandonment suit, varying with the location, many physiological characteristics of the individual, the type of suit involved, and the clothing worn under it. Survival time without a suit is probably several minutes. While abandonment suits do protect survivors from hypothermia for at least a minimal period, they vary considerably in effectiveness. Some float the wearer in a more or less horizontal position, either face up or face down in the water; some have hoods that trap water in front of the wearer's face; many are not watertight because of leaks around neck seals and other areas; most lack handholds for recovering survivors from the sea after they have been located and all are ill-fitting and bulky enough to hamper manoeuvrability and manual dexterity. Despite these inadequacies, abandonment suits are obviously necessary and attempts should be made to improve their utility. Dramatic innovations are needed; heat reflective fabrics, for example, are being developed which will release moisture in one direction yet be impermeable to water penetration in the other. Until such developments are introduced, however, short-term measures for improvement must be adopted and remedies found to the problems listed above so that abandonment suits become more watertight, better fitting, easier to grasp, and less restrictive to movement (Appendix D, Item 2).

On a clear, warm, windless day in a calm sea, any of the existing methods of rig evacuation can be carried out successfully, even direct entry into the sea. Unfortunately, the chances of an emergency occurring during ideal environmental conditions are slight and any realistic appraisal of evacuation capabilities must allow for "worst possible" conditions. Evacuation following a blowout or fire may occur in any weather; evacuation due to storms or ice will probably occur in environmental condi-

tions that are extremely unfavourable. Since the loss of the *Ocean Ranger*, there have been no significant improvements in the quality of escape systems in place on drilling units off eastern Canada. Admittedly there are now lifeboats for 200 percent of the crew, abandonment suits are mandatory, life rafts must be davit-launched and some lifeboats are stored perpendicular to the unit. These improvements, though commendable, do not ensure the safe evacuation of a rig under the conditions that prevailed on February 15, 1982, when the *Ocean Ranger* capsized. Real improvement of survival systems for offshore workers will require short-term equipment modifications of the types reviewed above, and significantly higher long-term priority in the planning and expenditures of both industry and governments.

The basic problem to be solved in designing and regulating evacuation systems for offshore rigs is the conscious determination of an acceptable level of risk. This process would require a realistic assessment of the risks involved in existing systems, a considered plan for diminishing them and a frank admission that there must be some residual level of risk in any escape and survival system operating in these environmental conditions. The acceptable level of risk and the definition of an adequate evacuation system for offshore must, ultimately, be determined by the state. Regulatory authorities and classification societies, over a lengthy period, have developed standards for the design, the construction and the equipment of drilling rigs which have met an acceptable level of safety and which, if operated by a well-trained and competent crew, should function safely in anticipated environmental conditions. This does not mean that drilling rigs will not be involved in accidents, or cannot sink. It means that the risk of their doing so is considered acceptable. But this does not relieve the state of the obligation to its citizens to ensure that action is taken to protect them, if the rig should, in fact, be evacuated or lost.

The offshore petroleum industry has faced and overcome the problems associated with exploring for and producing oil and gas under major environmental constraints because, without these solutions, exploration and production could not take place. Thus when a rig is being built, such equipment as telescoping risers, drill-string motion compensators, and in some cases dynamic-positioning equipment are deemed essential to the rig's mission and therefore worthy of the latest innovations that technology has to offer. The evacuation system does not meet that same criterion of being essential nor does it elicit the same response. Rig owners and operators contend that they install the best equipment available and ensure that it meets regulatory requirements. Rig designers contend that they design drilling rigs, not evacuation systems. Lifeboats and davit manufacturers lack the incentive and the capital to develop technologically innovative systems and instead make marginal improvements to existing lifeboat designs that will maintain their competitive standing in the marketplace while remaining consistent with regulatory requirements. The current *Canada Oil and Gas Drilling Regulations* for mobile offshore drilling units require that "Every drilling unit carry emergency equipment and lifesaving devices sufficient in number to permit the escape of all persons from the drilling unit under any conditions that may reasonably be anticipated." Conditions have, in fact, occurred in which the lifesaving devices were clearly inadequate; these conditions can be anticipated to occur again; the regulatory criteria, even in their general form, are therefore not being met. Lack of funding, of priorities, of incentives and of regulatory control have all combined to allow a defective system to continue.

The ultimate responsibility for remedying this situation and for providing the type of incentives that have led to dramatic technological advances in other fields rests with the state. Although some government-sponsored research and development in escape and survival systems has been carried out in Canada, the level of funding falls far short of the need. The source of the greatest effort in the development of new evacuation systems has been Norway, the smallest country engaged in offshore drilling. Research and development there has been funded by both government and

"Problem areas are widely recognized; it is reasonable to ask what is being done about them. In Norway, the response has been a major government-funded research and development project which has resulted in what is now the Harding free-fall lifeboat. There are some critical comments which can be made regarding this new system. Nevertheless, at this point in time, it is probably the best available solution to the escape and survival problem. Manufacturers of the conventional totally enclosed motor propelled survival craft (TEMPSC) have, on the other hand, tended to work on parts of the problem with the intention of improving existing systems. Nevertheless, no major new system development seems to have been initiated."

C. Shaar, Escape and Survival. Safety Offshore Eastern Canada Conference Proceedings, 1984

industry. In the United States, the United Kingdom and Canada, few incentives exist and even when industry or the lifeboat manufacturers do take the initiative to develop new systems or improve existing ones, the testing procedures and regulatory approvals are so lengthy, costly and cumbersome that many good ideas never advance beyond the design or prototype stages. The regulatory system thus operates to impede rather than to encourage development.

Government should set performance standards for lifesaving equipment and require that industry comply with these standards within a given period of time. This step should initiate a concerted program of research and development which may lead to a long-term resolution of the problem within the coming decade. Success will follow if the regulatory requirement is firmly formulated and if the research and development effort is adequately funded. This process should begin now.

Recent developments have essentially been improvements in the lifeboat rather than new ideas. Perhaps what is now needed are breakthroughs, and radically new concepts. The industrial world has marvelled at the ingenuity employed by the offshore oil industry in taming environmental forces and harvesting the seabed for man's productive use. Costs, while a consideration in reaching these goals, did not seem to impede progress. It is possible to achieve the same dramatic improvements in offshore evacuation systems; the technology that put man on the moon can surely meet the challenge of taking him safely off an ocean-based drilling rig. It took the *Titanic* disaster in 1912 to outrage society to the point that improvements were made in safety systems at sea, improvements that included lifeboats for 100 percent of those on board. It took the combined tragedies of the *Ocean Ranger* and the *Alexander L. Kielland* for countries controlling North Atlantic drilling areas to insist on abandonment suits for everyone on board and lifeboats for 200 percent of the crew so that rigs could be evacuated from alternate locations. In view of the technological advances that have been made in medicine, communications, aerospace, and engineering during those 70 years, one cannot help but question the level of commitment and motivation behind the comparative rate of progress in the evolution of marine safety equipment. There is a pressing need for systems that are simple, reliable, and above all, safe, to move people off a rig in distress in Canada's storm- and ice-ridden eastern waters; there is then a need for rescue systems that will find them, succour them and bring them safely home.

9

RESCUE

CHAPTER NINE RESCUE

A critical analysis of any component of a national search and rescue program requires a review of the whole of which it is a part, since funds and resources allocated to one part are not available to the others, and it is only in the context of the whole that the quality and the adequacy of the part can be judged. In the Canadian context national should not be confused, as is often the case, with federal. While a Search and Rescue (SAR) program will of necessity subsume a very substantial and indeed a critical federal role, means must be found to ensure that private and corporate citizens as well as local and provincial authorities assume their proper responsibilities within the framework of a national SAR program.

A fundamental principle upon which a free society is predicated is the intrinsic worth of the individual. It follows from this principle, at least in theory, that the affairs of society are to be so ordered that the life of no citizen, nor of any alien having legitimate business within it, is wittingly placed in jeopardy. Furthermore, where hazards may be encountered, reasonable precautionary measures are to be taken. The corollary naturally follows that, when a life is in peril, the resources of society will be mobilized in an effort to effect rescue and the cost will not be counted before action is taken. Logic and the imperatives of a free society dictate that an effective SAR program be national in scope and in organization, for its objectives are, beyond dispute, truly national.

Many obstacles lie in the path of formulating in Canada an integrated, well coordinated, and functioning national program. There are overlapping and sometimes competing departmental jurisdictions, interdepartmental rivalries and jealousies, powerful and influential national and international corporations, the potentially fractious liberties of free citizens in a free society, and an increasing dependence by citizens, private and corporate, upon the state to do for them what they should do for themselves. These obstacles are compounded by a vast underpopulated territory, much of it comprised of difficult and often hostile terrain; thousands of miles of coastline on three oceans, two of them ice-frequented and all three dangerous, and a harsh and unforgiving climate as befits a "Dominion of the North". Nevertheless, the task of formulating a national SAR program must be faced. It needs to recognize the responsibilities of the individual and of the community; the responsibilities of industry and finally the role of the state in the process of education, in the creation of public awareness, in the enactment and enforcement of laws and regulation and in the retention of that residuum of responsibility that it alone has the resources to exercise. That residuum includes the provision of major operational systems that will ensure that the state can meet its national and international obligations; the provision of facilities and resources adequate for an appropriate level of support to corporate efforts in the event of a major disaster and the provision of appropriate mech-

anisms for effective mobilization and co-ordination of all the resources, private and public, that may become available in a case of necessity.

The first responsibility is that of the individual for self-help, for the prevention of accidents, for cautious forethought, and for concern for the safety of others. The host of small craft that ply, whether for pleasure or profit, the coastal and inland waters of Canada not only constitute the largest single source of SAR incidents but, represent as well, the most intractable problems in respect of organization and control. Those who for whatever reason expose themselves needlessly to life-threatening hazards should have no illusions about the limitations of SAR resources and no doubt about the extent to which ventures are undertaken at one's own risk. Many tragedies in the past could have been averted through the proper exercise of individual responsibility.

What is true for the private citizen is by extension true for the community in which he lives and functions. No community can exist unless its members share an obligation to protect the whole through the protection of its individual members. This implies the maximum use of local resources to aid those in peril. This is as true for the province as for the village or town. Communal obligations become all the more pointed, however, in the case of organizations such as yacht and flying clubs which, because of the nature of the activities for which they exist, will inevitably require SAR resources. Indeed, where large numbers of pleasure craft are normally concentrated, as on Canada's West Coast, they constitute the preponderant source of SAR incidents. It is not unreasonable to propose that those who create organizations for the pursuit of leisure involving hazardous activity should create parallel organizations for the pursuit of safety. In short, all yacht and flying clubs should be required to create from their own resources a capacity to rescue their members in distress. In this context the potential significance of volunteer organizations should not be discounted. Some of those efforts will be co-ordinated through the Civil Air Search and Rescue Association and others through the Canadian Marine Rescue Auxiliary. These associations are important not only in operational terms but also in terms of public education and in the promotion of safety consciousness, and their efforts should be expanded. There are those who argue, on the analogy of the Royal National Lifeboat Institution,[1] that the volunteer role should be a preponderant part of a national search and rescue system. This institution, though excellent and demonstrating the highest levels of voluntary and self-help, is a system impossible to transplant. Its success is based upon some 160 years of cultivation and its traditions cannot be exported. Indeed, it might be argued that, where deeply ingrained concepts of state responsibility and of the individual's rights prevail, the soil for the development of that system in any modern state today, including the United Kingdom, would prove to be rather barren. What can, however, be undertaken through a program of education and a firm policy of self-help is a reinforcement of individual and communal responsibilities. A measure of cost recovery would emphasize that policy.

The responsibility of industry for safety is larger and more clearly defined than that of the private citizen, the community or the private clubs. A company has a major responsibility for the protection and safety of those who work for it, in the prevention of disaster and in the provision of aid, if one should occur. The law requires and self-interest dictates that all employers, in the provision of a safe workplace and in the adoption of proper procedures, assume responsibility for taking whatever measures are necessary for the safety of their employees. In the maritime context this implies preparedness for dealing with the emergencies of a hostile marine environment through the training of personnel, the provision of means of evacuation and the development of contingency plans. Where rescue becomes necessary, the fishing

[1]The Royal Naval Lifeboat Institution is a voluntary organization incorporated for the sole purpose of saving life and property at sea. It currently maintains 257 lifeboats on station along the coasts of the United Kingdom, Northern Ireland and the Republic of Ireland.

9.1 The Canadian Coast Guard maintains a number of small boats for rescue operations close to shore. Many of these incidents involve providing services to pleasure craft owners.

and shipping industries traditionally rely upon other vessels, ships of passage or federal SAR resources. Ocean-going vessels generally report their location regularly but fishing vessels do not. The success of rescue efforts is relative to the conditions that prevail, the ships that are near, the ready availability of federal SAR resources and the accuracy and timeliness of the information available regarding the location and activities of all privately owned commercial craft operating near the vessel in distress.

Although the maritime industry in general cannot reasonably be expected to provide from its own resources a total SAR capability, the offshore oil and gas industry is different. Large numbers of its workers are concentrated at known fixed locations which are distant from shore, and where environmental hazards may become extraordinary. Like all frontier industries, it is remote from public and private services that are otherwise available to render aid in life-threatening situations. Unlike traditional maritime ventures, companies engaged in offshore drilling operations off eastern Canada have under contract extensive marine and air resources in support and a vessel is required to be at the drill site at all times on standby duty. The rigs maintain daily contact with their shore bases and information, as needed, can be readily transmitted. The availability of support vessels and the quality of the communication system provide a degree of self-help and of protection to the rig and the crew, that in practice is not possible in the fishing and shipping industries. It is therefore reasonable, that in the first instance, the responsibility for rescue in case of emergency should fall upon the oil companies themselves. This does not absolve the state of its responsibilities but recognizes the need for an enhanced role for the oil industry in a co-ordinated national SAR program.

At the time of the loss of the *Ocean Ranger*, neither the oil companies nor the federal SAR services were adequately prepared to meet an emergency of that dimension. Despite the loss of the *Alexander L. Kielland* only two years earlier, a strange euphoria was pervasive. The mystique of unsinkability inhibited the kind of planning that was clearly necessary. Most glaring among the long list of deficiencies revealed in the investigation of the loss of the *Ocean Ranger* were inadequacies in the training of the crew, in contingency plans and the training of key personnel on shore, in emergency procedures and co-ordination of rescue efforts, in the command structure, and

9.2 Fast rescue craft (FRC) provide a rapid, highly mobile method of recovering survivors from the water or from a TEMPSC. The safe deployment and retrieval of these craft, and co-ordination between the crews of the FRC and of the standby vessel, depend on training and regular drills in realistic conditions.

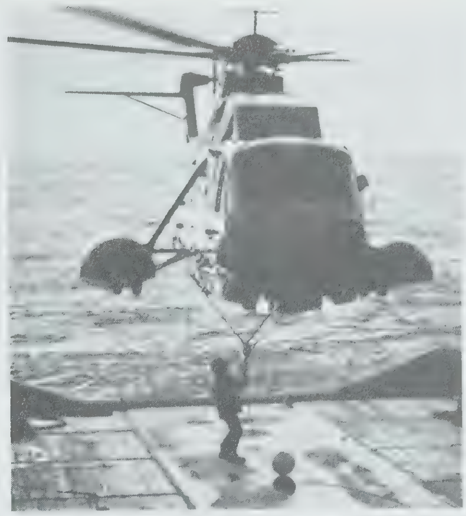
in the escape and survival systems. Some of these deficiencies were specific to the *Ocean Ranger*, while others were general and pertained to the industry as it then operated.

The standby vessels that at that time served the rigs on the Grand Banks, on the Scotian Shelf and off Labrador were designed to provide anchor-handling, iceberg-towing and supply services; neither in structure nor in equipment were they designed for effective rescue services. Their cargo rails obstructed rescue attempts from the sea and few had removable bulwarks to enable the crew to reach survivors. Rescue equipment was meagre, if not non-existent, and the crews had no rescue training. Medical facilities and provisions were in short supply and there were no paramedical personnel on board. The helicopters under contract had no rescue equipment, the pilots were untrained in rescue techniques and there were no trained rescue technicians available. There was no co-ordination of contingency plans between the oil companies and the drilling contractors nor with federal SAR. Senior industry personnel on shore were not equipped by training or experience to perform the duties expected of them in the event of a major disaster.

Since the *Ocean Ranger* disaster the oil industry has assumed an increased responsibility for first-line help in an emergency and significant measures have been taken to augment and upgrade equipment and procedures; yet much remains to be done. Studies have been undertaken by industry to assess the safety, survival and emergency response systems of the operating companies and recommendations made for action to be taken. When helicopters cannot be used to evacuate a rig, the standby vessel is considered, in the North Sea and off eastern Canada, to be the first-line resource to assist in the rescue and accommodation of all personnel from the rig for which it is responsible. The standby vessel is also intended, off eastern Canada, to assist in the avoidance of collisions with ice or other vessels. Closer attention has been paid since 1982 to the ability of a standby vessel to perform these functions. Guidelines now state that it should keep station no more than one nautical mile from its rig or at a distance such that the time for return to the drilling rig does not exceed 20 minutes. This is a clarification of the 1980 Regulation which specified neither an appropriate standby distance nor a return time.

The standby vessels are, however, generally unchanged; their propulsion and station-keeping abilities are adequate but their structural characteristics remain unsuited for rescue functions. Fast rescue craft (FRC) and crane-operated rescue baskets are now required and are installed. This equipment has undoubtedly improved the rescue capability of the standby vessels, but concerns have been expressed about the effectiveness of the system for launching and recovering the

9.3 The EMPRA and similar devices enable persons in the water to be picked up and transported by air to nearby rigs or supply vessels. EMPRA are kept ready for use at all helicopter bases serving the East Coast offshore, including Sable Island, and on all drilling rigs and supply vessels.



"An. . .area of concern with respect to the use of supply vessels in the standby role has to do with the effectiveness of their recovery equipment and techniques. Industry has adopted the latest, state-of-the-art equipment but industry and government agencies both expressed concerns that the level of training and development of the support vessel crews is not in keeping with the stage of evolution of the equipment."

An Evaluation of Industry Safety Management in Eastern Canada Offshore Drilling Operations. Manadrill Drilling Management Inc. 1984

FRC under storm conditions and there are also technical problems with the crane-operated rescue basket system, which need early resolution. Questions have been raised regarding the quality of training and of drills provided for the crews in launching and recovering the FRC under storm conditions.[2] Effective use of the FRC and of the rescue baskets in a storm requires a crew that is highly trained, experienced and regularly drilled. There is also the question of the ability of a normal crew complement of a standby vessel to deploy and recover the FRC, to maintain and manoeuvre the vessels, to recover survivors from the sea or from the FRC and to administer first aid. These questions and concerns need to be addressed by the regulatory authority.

Since 1982 the helicopters serving the rigs have been upgraded for rescue. They have been outfitted for a hoist which can be installed in less than twenty minutes whenever it is required and the crew is trained in its use. The hoist is used to lower a Billy Pugh basket to the sea for those survivors who can climb into it and be hoisted up, but no rescue technician is provided to help the helpless. The industry is now able to employ the emergency multiple person rescue apparatus (EMPRA), which may be suspended from a helicopter on an external hook and can hold 15 to 20 persons. Persons can climb into this apparatus from the deck or from the sea or be scooped up from the sea, if they cannot help themselves. This apparatus enhances rescue during calm weather, but the helicopter can transport survivors in it only for a relatively short distance because of reduction in the speed of the helicopter and the risk of hypothermia to the survivors. Concerns expressed regarding the effectiveness of the EMPRA under storm conditions need to be addressed. Industry helicopters can also drop standby emergency assistance (SEA) kits to aid survival.[3]

The helicopters which are used for regular crew transport are twin turbine, single-rotor aircraft, the Sikorsky S-61 and the Aerospatiale Super Puma, each equipped with an automatic flight control system. De-icing equipment, auto-hover systems, and continuous duty hoists are available, but they are not standard equipment. The installation of this additional equipment, though increasing the rescue capability, would reduce the load-carrying capacity of the helicopters. Communication, navigation and other avionics equipment is similar on both types of helicopters but the Super Puma with a cruising speed of 135 knots and a normal radius of action of 285 nautical miles is considered to be superior as a rescue vehicle because it can

[2]Only three crew members are required to receive FRC training. Practice drills in the use of the FRC are at the master's discretion and are generally conducted only under ideal conditions.

[3]These kits consist of four interconnected packages comprised of two life rafts connected by a long line with floating equipment pods. They are stored at the airports, on the rigs and on Sable Island.

reach all points on the Scotian Shelf and on the Grand Banks without refuelling (Appendix D, Item 3). These helicopters under contract to the industry constitute a secondary source of SAR resources in the event of a major disaster. Their crews need to be trained regularly in rescue functions.

It was recommended in Report One that a full-time dedicated search and rescue helicopter be provided by either government or industry, fully equipped to federal SAR standards, and readily available with a trained crew able to perform all aspects of rescue. Since December 1983, industry has been required by COGLA to provide a full-time helicopter for rescue purposes. COGLA has not, however, issued specific guidelines regarding the level of service to be provided by this helicopter. The oil companies accordingly arranged with the helicopter contractors to have one helicopter on standby but only when helicopters are flying to and from the rigs. The helicopter is "designated" and not "dedicated". This fact allows the helicopter contractor to re-assign the standby helicopter to meet the requirements of the operator. Current industry practice allows the designated helicopter to be used for regular crew transport if another helicopter, capable of filling the standby role, is within sufficient flying time of the airport to allow it to respond to a rescue mission within 30 minutes. When there are no regular helicopter operations, a standby crew for the designated rescue helicopter is on a one-hour call out but they are not stationed at the airport. The standby crew does not include a rescue technician. The provision of a standby helicopter on a rotational basis by several helicopter contractors, only while helicopter operations are being conducted, does not constitute a full-time rescue capability for offshore drilling operations. The absence of rescue technicians also reduces the industry's capability to provide rescue services offshore. A better solution should be found.

Appendix F(2) Provisions for Common Response/Alert Plans, Flight Following and Ice Management. "Where more than one operator is active in a particular area, the adoption of common response/alert plans, flight-following, and ice management services are required. This program of joint emergency preparedness should be complemented by operator equipment resource-sharing arrangements."

Drilling for Oil and Gas on Canada Lands, Guidelines and Procedures. April 1984

A major improvement in the ability of industry to respond to emergencies has been the creation of a series of multilateral agreements between the several oil companies to provide for the integration of contingency planning and procedures for action and for the elimination of legalistic, contractual and other roadblocks that would impede joint action. The East Coast Operators Management Committee co-ordinates these objectives and through various committees there have evolved common response procedures for emergencies. It is evident that industry has exceeded regulatory requirements in this area of emergency response. It is unfortunate that there has not been closer collaboration with government in the development of these common policies and shared procedures to effect greater co-ordination with federal SAR. Steps should now be taken by both industry and government to test the effectiveness of the system and to train, through simulated exercises, key personnel in their essential roles in the event of a disaster. Recent exercises have identified potential and actual weaknesses in the system, particularly in its integration with federal SAR and in lines of communication, which need to be rectified. It is, however, imperative that these auspicious beginnings be pursued and that industry be encouraged to continue the development of common policies and procedures that will make joint emergency responses more efficient, minimize the possibilities for confusion, and facilitate the adoption and administration of optimum standard safety policies. In this way the oil industry will become an important integral component of a national SAR program and the safety of those engaged in offshore oil operations will be enhanced.

The final responsibility for rescue is that of the state; its obligations touch all the others and, in some particulars, transcend them. It retains that residuum of responsibility that it alone has the resources to exercise. The responsibility of the state for rescue is exercised in Canada by the federal government. Since 1947, a federal SAR capability related to air traffic was developed to meet Canada's obligations to the International Civil Aviation Organization. The initial responsibility was assigned to the Royal Canadian Air Force and continues to be a function of the Department

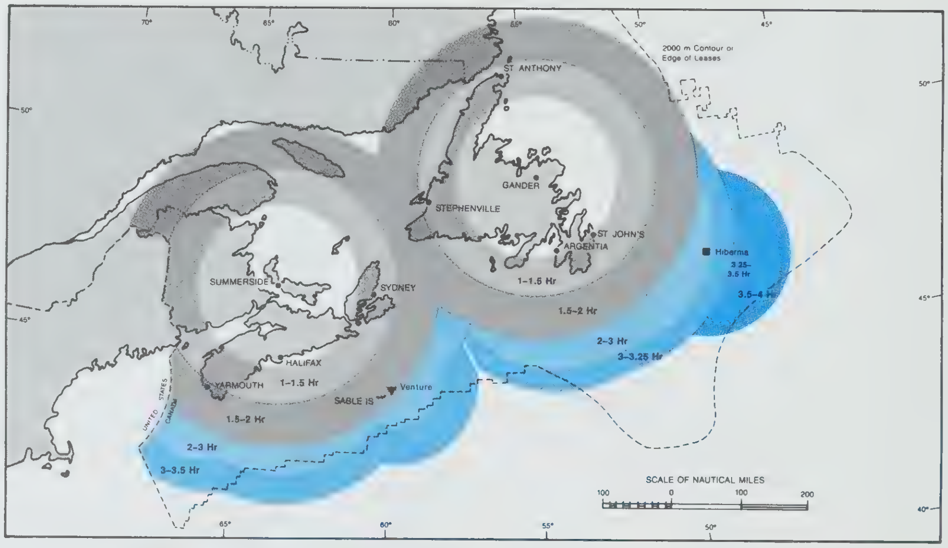
9.4 Emergency response exercises involving rigs, supply vessels, helicopters, fast rescue craft, and government SAR resources provide valuable training and identify weaknesses in emergency response plans.

of National Defence. Federal involvement with marine SAR has a longer history, deriving primarily from local needs for water rescue service, then growing to meet the demands of commerce and of international agreements, with services being provided by the Marine Administration of the Department of Transport. Federal SAR has been so organized that the Department of National Defence is responsible for co-ordinating all air and marine search activities in Canada and in adjacent areas for which Canada has accepted responsibility under international agreements and for providing dedicated air resources to respond to both air and marine distress incidents. Subsequently, the Minister of National Defence has become the lead minister and the government spokesman on SAR.

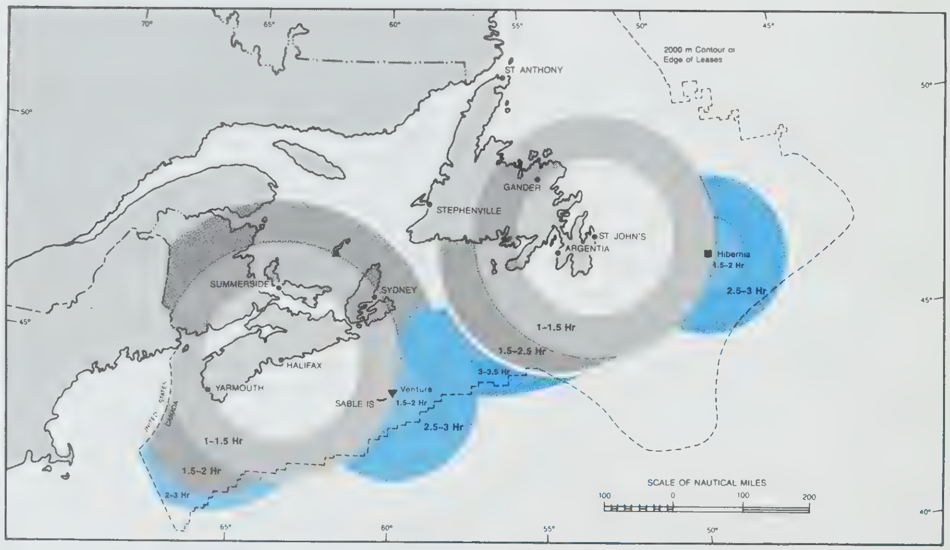
The prime objective of federal SAR is to aid persons involved in air and marine incidents within the area of Canadian responsibility. Since most SAR incidents, as presently defined, are generated by the inexperienced or the imprudent, federal SAR seeks, through governmental and other agencies, to foster the prevention of incidents through education and regulations. It also aims to relieve human suffering in emergencies through the provision of mercy flights and to aid civil authorities in the search for missing persons on land or at sea.

The federal SAR system is organized into four Search and Rescue Regions with a Rescue Co-ordination Centre (RCC) at Victoria, British Columbia; at Edmonton, Alberta; at Trenton, Ontario; and at Halifax, Nova Scotia. At present the federal government has dedicated 42 vessels and 24 aircraft to a primary SAR role. The vessels are owned and operated by the Canadian Coast Guard, while the Department of National Defence owns and operates all primary air resources. These resources are distributed amongst the four regions on the basis of a debatable interpretation of statistics of incidents and on the basis of estimates of clients to be served, which do not include, except in a passing fashion, persons involved in offshore

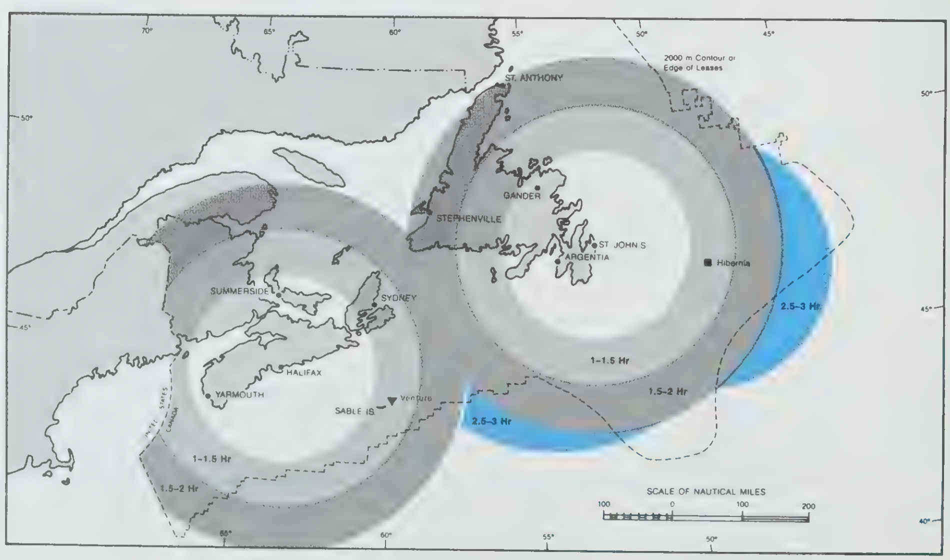
9.5 The SARCUP helicopter, an upgraded Labrador/Voyageur CH113, has an average still-air speed of 115 knots and an endurance time of 5 hours, 12 minutes to zero-fuel. The information in this and the following two illustrations assumes that a rig is present at Hibernia, and that there is a base at Sable Island, for refuelling. The outermost rings in these illustrations do not necessarily represent the maximum possible endurance of these helicopters, but are based on the Instrument Flight Rules requirement that each helicopter must file a flight plan designating a primary and an alternate landing location. Shading has been used to help differentiate between adjacent rings.



9.6 The Sikorsky S-61 helicopter has an average still-air speed of 115 knots and an endurance time of 5 hours to zero-fuel.



9.7 The Aerospatiale Super Puma helicopter has an average still-air speed of 135 knots and an endurance time of 5 hours, 30 minutes to zero-fuel.



oil exploration. In addition, National Defence and Coast Guard and other government departments have designated some of their resources as having a secondary SAR role.

The primary SAR air resources available to RCC Halifax at the time of the loss of the *Ocean Ranger* were three Labrador/Voyageur helicopters at Gander and three Labrador/Voyageur helicopters and three Buffalo aircraft at Summerside. There were Auroras at Greenwood, Nova Scotia, and also Sea King helicopters at Shearwater, Nova Scotia in a secondary SAR role. To provide air response 24 hours per day, 7 days per week and 365 days per year, and to maintain the capability of having one helicopter ready to take off with a high degree of reliability, a SAR helicopter unit, it is contended, must have a minimum of three helicopters and five crews.[4] The number of crews required to man three helicopters depends upon the length of the standby.[5]

The Labrador/Voyageurs are twin turbine, tandem-rotor amphibious helicopters with a normal cruising speed of 115 knots and an operating radius of approximately 225 nautical miles. They carry a full complement of rescue equipment and normally a crew of five, consisting of pilot, co-pilot, two search and rescue technicians (SARTECHs) and a flight engineer. These helicopters were manufactured some twenty years ago and have undergone extensive renovations under the search and rescue capability update program (SARCUP), which was launched in 1976 by the federal government. At the time of the loss of the *Ocean Ranger*, they were in the process of being rebuilt from the basic air frame and provided with upgraded equipment. The Labrador/Voyageurs are no longer being produced and spare parts are difficult to obtain. To maintain them to Department of National Defence standards requires, therefore, a rigorous maintenance program, involving long periods of time when a helicopter is not available for duty. The helicopters did not, in 1982, have radar, automatic flight-control systems, hover-coupler systems or VHF/FM marine band radios.[6]

The Buffalo fixed-wing aircraft is well suited for its search role with radar, Loran C and radio equipment; it can also drop SEA kits and life rafts to survivors at sea. The Aurora is capable of performing visual and electronic searches for extended periods and can be used as the "on-scene commander". It has forward-looking infrared sensors which can be used to locate persons in the water. It is also equipped to drop SEA kits and life rafts. It has, however, limited visual search capability because of a lack of spotter windows and its high speed. The Sea King helicopter has a range of only 170 nautical miles, but with much of the same equipment and with auto-hover capability it is better equipped to perform sea rescue than the Labrador/Voyageur.

Federal SAR helicopters can reach the Hibernia area and most drilling locations along the Scotian Shelf within two to three hours' flying time. Locations on the southern Scotian Shelf and on the Grand Banks east and south of Hibernia may take as long as four hours' flying time to reach. These times are in addition to the 30-minute and 2-hour standby times. The southern Grand Banks and the Flemish Cap are beyond the range of these helicopters, without refuelling en route.

The crews of the helicopters and fixed-wing aircraft used for search and rescue are highly trained. In addition to basic training, a pilot completes a 35-day specialist course and, after one to three years' experience as a SAR pilot, can be upgraded to

[4]This arrangement will make possible the provision of a response at 30 minutes' notice during working hours and at two hours' notice during off-duty when at least one crew will be on call at home.

[5]For a 30-minute standby, 8 hours per day every day of the year, 6 crews are required.

[6]Radar allows a pilot to fly below cloud cover at night because he can differentiate and locate high ground. An automatic flight-control system and hover-coupler system allows a helicopter to hover in a fixed position close to the water without pilot assistance. VHF/FM marine allows a pilot to communicate directly with vessels during a rescue attempt.

9.8 Helicopters under contract to the industry can be equipped with a hoist for recovering survivors from the water, but only government SAR helicopters currently carry a trained rescue technician who may be lowered to provide assistance.

Aircraft Commander. Continuing training and regular proficiency checks are required. SARTECHs will have completed a 35-day preselection course on survival and diving and a 120-day SARTECH course of training that includes survival techniques, medical treatment of survivors and hoisting from a helicopter, followed by a 21-month apprenticeship to a senior SARTECH. SARTECHs must also undertake continuation training and undergo regular proficiency checks.

The Canadian Coast Guard, as a part of the federal SAR program, had in the Halifax Search and Rescue Region, at the time of the loss of the *Ocean Ranger*, a number of small rescue boats which, based at various locations along the coasts, were used for rescues close to shore. There were also four ocean-going Coast Guard vessels, assigned to search and rescue duties, which patrolled the territorial waters off the East Coast of Canada. Of these, two – the *Grenfell* and the *Jackman* – are former offshore supply vessels, while the *Alert* was designed and built for search and rescue duties. The fourth, the *Daring*, is no longer in service. All three current vessels have twin screws and bow thrusters. The vessels are equipped with firefighting equipment, portable pumps, first aid equipment, diving equipment, line-throwing apparatus, scramble nets, and life rafts. The *Jackman* and the *Grenfell* are equipped with crane-launched rigid rescue boats and inflatable boats; the *Alert* has two inflatable rescue boats, but will not have a FRC until its 1985-86 refit. All three vessels have facilities for helicopter winching and the *Alert* has a helipad. The *Grenfell* is equipped with a rescue basket but the other vessels are not. The presence of bulwarks in the rescue zones of all three vessels makes it difficult for survivors to climb aboard directly from the water and for rescuers to render assistance. These vessels are not as fully equipped for rescue as the supply vessels used by industry. The officers of the Canadian Coast Guard SAR vessels are highly trained, but the majority of the seamen have not completed the BOT, BOST or any other basic course in marine training nor in rescue techniques as required in the North Sea. The men are trained on the job through drills and shipboard exercises.

Since the loss of the *Ocean Ranger*, the Canadian Coast Guard has added a new primary SAR vessel, the *Mary Hichens*, replacing the *Daring*, which will be used for SAR duties off the coast of Nova Scotia. The vessel, originally designed as a supply vessel, was converted by the Coast Guard for rescue operations. It is equipped with firefighting equipment, two fast rescue craft, two rescue baskets, and a medical

treatment area. The vessel's original design was altered to accommodate a helicopter landing zone and two rescue zones.

Since 1982, more of the Labrador/Voyageurs have been refurbished and re-equipped under SARCUP and provided with improved radio and navigation systems but they are still not suitably equipped for offshore SAR duties. They continue to lack an automatic flight control system, all-weather flying capability and doppler auto-hover equipment which is not currently available for this model. Another deficiency is the Labrador/Voyageur's relatively short range and its lack of endurance for marine rescues offshore. There are also weather limitations, because these helicopters are not permitted to fly when there is icing, present or forecast. The Labrador/Voyageurs are also limited for start up and shut down, by manufacturer's specifications, to steady winds of 52 knots. The presence or forecast of gusts will reduce that limitation to 30 knots when the gust spread reaches the allowable maximum of 15 knots. A hangar exists at Summerside, but not at Gander, in which a helicopter can start up should these wind conditions prevail.

The deployment of these federal resources is determined by many factors. Weather and operating limits are important considerations in the siting of aircraft as is the availability of support infrastructure for their maintenance and general servicing. The presence of alternate sources of rescue affects the location of marine resources. Prime factors apart from political intervention are the number of clients to be served and the need for these resources as perceived by those in authority.

The number of clients to be served will be influenced by the density of population and the concentration of activities. The potential marine client population is defined, in short, as all those who earn their living on the sea or use the water for recreation. The largest potential client population, for example, in the Victoria and Trenton regions, are the occupants of pleasure craft, while the largest potential group in the Halifax region, and the second largest nationally, is the fishing community. Basically, the potential marine client population is governed by the expressed purpose of federal SAR activities, which is stated to be:

> to prevent the loss of life and injury through search and rescue alerting, responding and aiding activities which use public and private resources; including where possible and directly related thereto, reasonable efforts to minimize damage to or loss of property, and by ensuring appropriate priority to aviation and marine safety measures focused on owners and operators most commonly involved in SAR incidents.[7]

The inclusion of protection of property in the stated SAR objective is of some consequence, because, in the planning, development and utilization of resources, it should be clearly understood that the overriding objective is to provide a lifesaving rather than a salvage service. Admittedly, there are instances where the two are inextricably interwoven; yet there are cases where they are not. There should be no doubt that government SAR is centred on the saving of lives.

It cannot be denied that accurate and continuing analysis of SAR incidents is essential for comprehensive planning, for properly assessing and determining operational requirements and for guidance in preventive action. An appropriate weighting system must, however, be devised, both for concentrations of SAR-related incidents and for concentrations of marine activities and clients, to assess the hazard to life associated with each accident. That weighting system does not yet exist. It is indeed apparent that the manner in which statistical data have been assembled, correlated and analysed contributes to invalid conclusions and does not provide a rational or

[7]Cabinet Committee on Foreign and Defence Policy, 1982. *Report on an Evaluation of Search and Rescue*, "the Cross Report".

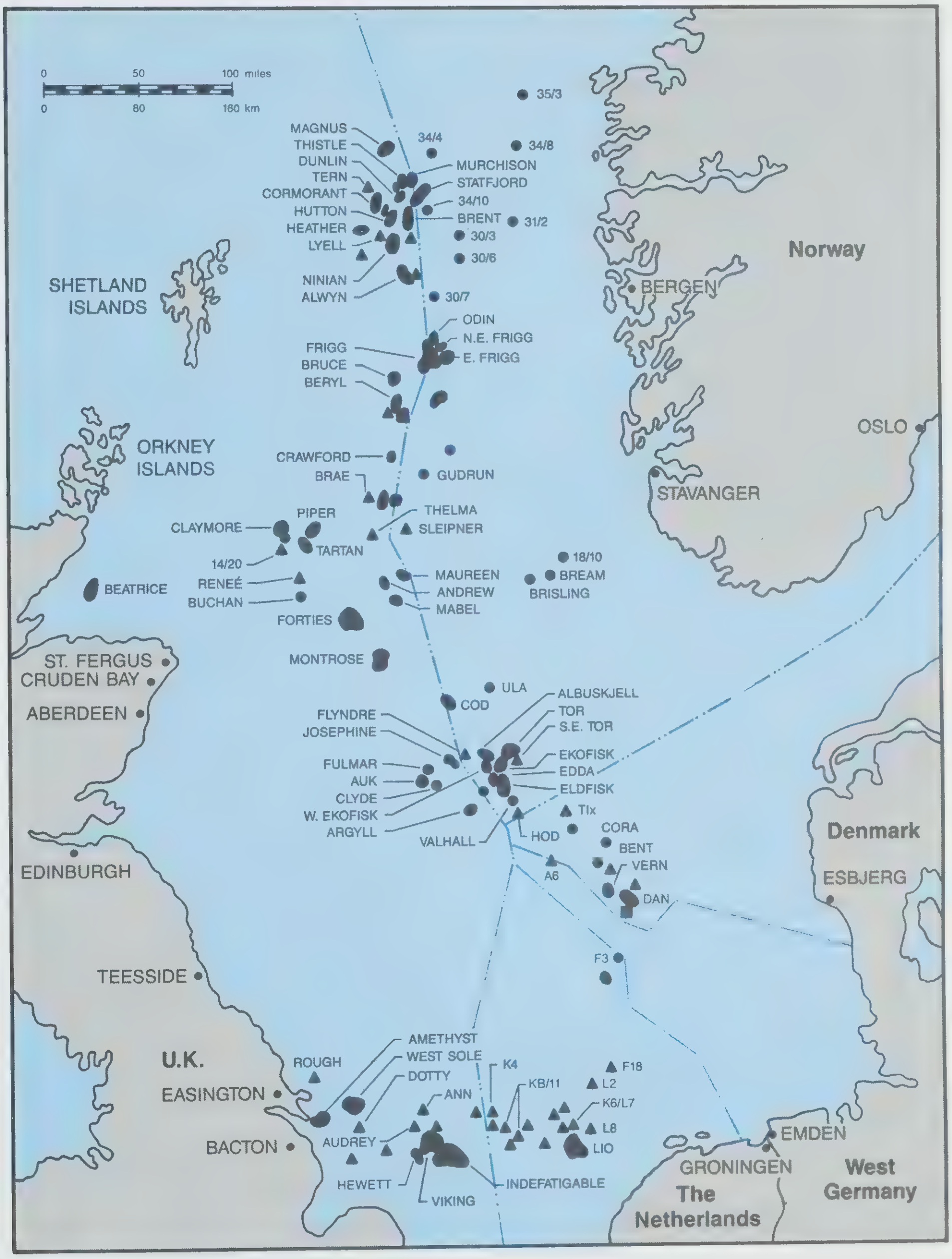
trustworthy basis for decisions regarding the deployment of limited resources. It is largely because of weaknesses in the statistical basis of decisions that serious criticism of the criteria for deployment of SAR resources has arisen.

It is of interest and possibly of enlightenment to compare Canadian SAR with what has evolved in the North Sea countries. There are, of course, vast differences in demography and geography to take into account, in the manifold traditions and in the scale of activities both in the near and the far offshore. Nevertheless a comparison can be instructive in illustrating how these countries have organized resources for emergency response. The oil and gas fields in the North Sea are now in the production phase and contain some 140 installations and approximately 15,000 people. The fields are generally within 1½ hours' helicopter flying time of five countries which border the North Sea. These countries have developed co-operative plans of mutual aid in the event of marine disaster. During the early years of development in the North Sea, industry tended to look to governments for SAR services to the far offshore. But it was generally recognized, as the industry developed, that the oil companies, with vessels and helicopters under contract, should provide response in the first instance and that the government SAR would supplement their efforts and responsibilities during the exploration phase. The oil companies have, over time, improved their self-help capabilities, organized sector clubs, and negotiated arrangements among themselves for mutual assistance and mutual sharing of resources in an emergency. They are now in the production phase and industry helicopters with SAR capability and trained crews are stationed on selected fixed production platforms.

The complicated organization and system of delivery of government SAR services are, particularly in the United Kingdom, the result of traditions, of density of population and of the magnitude of activities in the near offshore. Traditionally, volunteers through the Royal National Lifeboat Institution play a major role. In the United Kingdom overall Ministerial responsibility for policy on civil marine and aviation safety, including search and rescue, lies with the Secretary of State for Transport. Its marine SAR responsibilities are co-ordinated by its Marine Directorate and Her Majesty's (HM) Coastguard. HM Coastguard has no dedicated SAR vessels, as the Canadian Coast Guard has, but utilizes the resources of other agencies. It co-ordinates marine rescue activities through six Marine Rescue Co-ordination Centres. The Ministry of Defence, by an interdepartmental agreement has held, since 1947, the responsibility for all civil aeronautical incidents. Accordingly, the Royal Air Force maintains two RCCs and 18 dedicated helicopters on continuous standby, 2 per squadron, ready to fly at 15 minutes' notice by day and 45 to 60 minutes by night (compared with Canadian standby times of 30 minutes by day and 2 hours by night). These Sea King and Wessex helicopters can be tasked, when needed, by HM Coastguard, but throughout the rescue operation they remain under the control of the appropriate RCC. The Royal Navy maintains dedicated Wessex helicopters which can be tasked by HM Coastguard. There is also a Nimrod, the counterpart of the Aurora, at one-hour standby by day or night and a second Nimrod is at six hours' readiness. Where the U.K. Department of Transport uses resources of the Ministry of Defence, it pays for them and where it needs SAR air resources in areas that have no military requirements, as off the Shetlands, it charters commercial helicopters. On the Shetlands a commercial dedicated helicopter, fully equipped with winch, auto-hover, direction-finding, flight-tracking and infra-red sensors and radar equipment and fully manned with a trained crew is on 15-minute standby by day and 45-minute standby by night.

In Norway, SAR responsibility rests with the Ministry of Justice and Police which has two RCCs, manned by personnel from military and communication agencies in spacious, well-equipped control centres and controlled by the Police. Dedicated Sea King helicopters, bought by the Ministry of Justice and Police and operated by the Air Force, are on 15-minute standby by day and 1-hour by night. These heli-

9.9 The North Sea is divided into five search and rescue zones administered by the United Kingdom, Norway, Denmark, West Germany and the Netherlands. Industry resources also play a significant role in North Sea search and rescue.



copters, two per squadron, are fully equipped and are each manned by a trained military crew of five. Marine SAR services on the other hand are provided by a volunteer organization, the Norwegian Society for Sea Rescue, which is supported 60 percent by government and 40 percent through charitable donations. Coast Guard and naval vessels can be tasked for SAR duties.

The Canadian federal SAR system, a product of the post-war period, has had to contend with extremes of weather, with vast unpopulated areas, with large ocean expanses, with sparseness of coastal population and with a relatively low concentration of activity offshore. The total available resource for primary SAR roles is not overly impressive nor does superior technical efficiency compensate for its paucity. Indeed, with few exceptions, neither the vessels nor the aircraft designated for primary SAR roles were designed for that specific purpose. Rather they were intended to serve the more normal operational requirements of the Department of National

Defence or of the Coast Guard. Levels of service have not been established nor have criteria been determined as a basis for evaluating the quality of service rendered. What, in fact, has been delivered is a set of discrete SAR activities or services provided by the two departments directly involved rather than an integrated program developed to provide adequate and timely response in the event of a disaster.

Much has, indeed, been accomplished in the promotion of public safety awareness, in the encouragement of volunteer associations, in technological improvements in equipment and rescue apparatus and in respect of co-ordinated approaches to an integrated SAR program. The stubborn fact remains, however, that no single agency for developing, implementing and controlling a national SAR program is yet in place. There is no single functioning agency with the mandate to knit together the several components into a comprehensive SAR program. The federal government has been aware of this need and, in 1976, established the Interdepartmental Committee on Search and Rescue (ICSAR) to facilitate co-ordination and to provide advice to a Cabinet Committee on SAR policy, planning and resources. A major study conducted during 1980-82, *Report on an Evaluation of Search and Rescue*, to evaluate SAR recommended *inter alia* the establishment of a national SAR program that would encompass the efforts of government, industry and volunteer associations towards an integrated approach to SAR problems. That report was specific regarding how an integration of all resources for clearly defined SAR roles would promote a framework for improved planning, for more objective choices of goals and for better selection of equipment. It was also specific regarding how a national SAR program would achieve a greater use of existing non-SAR resources and how greater participation by the private sector could be encouraged and the prevention of incidents enhanced through educational and regulatory measures to increase public awareness of safety. Notwithstanding acceptance of the report by the federal government and endorsement by the Cabinet of the concept of a national SAR program, appropriate measures to put it into effect have not yet been initiated.

"In Canada, the SAR Program is a collection of activities performed by several departments, developed historically from individual air and marine requirements. . . .In many other countries (e.g. U.S.A., U.K., Australia) the National SAR Plan is limited to a definition of the SAR responsibilities of various national, provincial and local authorities and such responsibilities are clearly set out in a national SAR Manual. Thus while Canada has gone further than other countries in co-ordinating federal government efforts and resourcing through its national SAR Plan, the plan does not describe the role of other authorities, nor indicate the resources available to them for SAR."

Report on an Evaluation of Search and Rescue. Cabinet Committee on Foreign and Defence Policy, September 1982

What is now required is a distinct integrated structure, under a lead minister who is not otherwise directly involved in the delivery of SAR services and who is consequently not involved in any conflict of interest, potential or actual, in setting priorities for government policies and spending. Managers are required for the national SAR program, who have no inherent conflict of interest between their departmental obligations and their responsibilities for any SAR-related activities. A discrete program identity with a discrete budget is needed for establishing both policies and related expenditure levels in order to permit evaluation of SAR as a distinct element of the appropriate financial envelope by the Cabinet subcommittee responsible for that policy. In this way SAR requirements would, for the first time in Canada, be assessed in their own right and in the context of SAR policies alone. For the first time SAR vessels, helicopters, equipment, and facilities would be assessed primarily in terms of their suitability for SAR functions and not as resources designed and acquired for other purposes and adaptable to SAR purposes, if nothing better became available. With a distinct administrative structure and a distinct and separate funding mechanism in place, it would then be possible to identify objectives and range of services, to develop scales of self-help, to define levels of service and to create a comprehensive data base with storage, analytical and retrieval capabilities to meet policy and operational needs; in short, to create a national SAR program.

The question, basic to this report is what, within the framework of an integrated national SAR program, is to be the role of the operating oil companies and of federal SAR in enhancing the opportunities for the rescue of those involved in offshore drilling operations. An analysis of the British and Norwegian systems reveals features that might help to provide an answer. The first line of response must, because of the distance of operations from shore and the resources immediately available, rest of necessity with industry. The capability, therefore, of the standby vessels, the

9.10 Industry resources provide the first line search and rescue response for the East Coast offshore.

level of training of their crews, the practical quality of rescue equipment on board must be of the highest possible order and acceptable to the regulatory agency. Accurate and timely information is essential for prompt operational response to SAR requirements. This need imposes a heavy responsibility on those who have the obligation as well as the means, to provide the information. That means should encompass the emergency position indicating radio beacon (EPIRB), the emergency locator transmitter (ELT) and the personal location beacon (PLB). The timeliness of an operational response in cases of distress in the North Atlantic is obviously of critical importance. To this end, effective contingency plans need to be co-ordinated amongst the operating oil companies and drilling contractors and government SAR. Exercises based on these plans to cope with simulated disasters are also crucial to the training of key personnel, to the testing of communications and to the evaluation of joint plans themselves. The response to an offshore disaster will involve all available helicopters for rescue purposes. The industry should therefore continue with its efforts in providing all helicopter crews, pilots and hoist operators, with basic rescue training.

Before the loss of the *Ocean Ranger*, government SAR resources had been developed and deployed primarily to help those in need of their services whether on land or near the coast. There existed no plan for a major disaster far offshore; help would simply be provided to the extent that it was feasible. The present deployment of federal air resources in the Halifax Search and Rescue Region is consequently inadequate to serve the offshore oil and gas industry. The present location of helicopters and fixed-wing aircraft may indeed reflect the optimum deployment in respect of covering the majority of marine distress incidents as determined on the basis of questionable historical data. The Grand Banks and the Scotian Shelf are areas that in fact have had the smallest concentration of incidents. The more serious risks and the largest concentration of dangerous activities will, in future, arise in the offshore oil and gas fields and intervening areas and may affect rigs, service vessels or helicopters. The loss of the *Ocean Ranger*, the supply vessel, *Seaforth Jarl*, the seismic vessel, *Arctic Explorer*, and the ditching of a helicopter on the Scotian Shelf give ample evidence of the need for more attention to the risks involved offshore.

The relocation of SAR resources to St. John's and Halifax would provide optimum coverage for the oil and gas industry. On the other hand, it would represent

a significant decline in the level of service along Newfoundland's West Coast and along the North Shore of Quebec and the Gulf of St. Lawrence. Since such a decrease in service would clearly be unacceptable to the public, alternative solutions to the problem must be sought. During the winter of 1984-85, a helicopter was transferred from Gander to St. John's on a routine basis and a second fixed-wing Tracker aircraft was located there for the winter months. The Commander of the Halifax Search and Rescue Region had the authority to use the helicopter as operational circumstances dictated. That was an interim expedient measure. The Tracker aircraft, normally used for fisheries patrol, has a range of 1,000 nautical miles, mediocre radar equipment but is without spotter windows and the capability of dropping SEA kits.

What, in short, is needed is a SAR service to the offshore oil industry that is supplemental to those offered to other clients and that will not detract from the predetermined level of service to those clients. It was stated earlier that the Labrador/Voyageur is unsuited for marine rescue duties offshore. These helicopters completed their capability update program (SARCUP) in June 1984 but they continue to lack many of the technological advances of the past two decades. They lack the auto-hover capability which every offshore SAR helicopter should have, their range is relatively short and they lack endurance for marine rescue offshore. What is now necessary is that government make available by acquisition or by chartering, as is done by the United Kingdom in the Shetlands, long-range helicopters instrumented and equipped with the most recent technology, each manned to federal SAR standards to carry out all aspects of search and rescue, for the Grand Banks, for the Scotian Shelf and for the Labrador Sea while drilling is taking place. These helicopters, at least one for each area, should be on 15-minute standby by day and not more than 45 minutes by night.

Whatever SAR system evolves, there remain the inescapable facts that there are physical limits beyond which the response time cannot be reduced and that it is of critical importance to extend survival time to the absolute limits that science and technology will permit. Administrative structures, policies, regulations and standards must be improved in combination with research into and with development of survival equipment, rescue resources and delivery systems so that, even in the hostile environment of the Northwest Atlantic in winter, the wait for rescue may not be a hopeless prelude to death.

10

REGULATORY REGIME

CHAPTER TEN REGULATORY REGIME

Any inquiry into ways and means of enhancing safety in offshore exploratory drilling operations leads of necessity to a thorough reconsideration of the regulatory regime currently in place for ensuring optimal safety and security for the men and machines engaged in these operations. The purpose of this inquiry is not to spell out a detailed prescriptive code of conduct but rather to lay out the multifaceted considerations that must be taken into account in developing a safety regimen adapted to the special conditions affecting exploratory drilling off eastern Canada.

Regulation and control of offshore exploratory operations in the countries under review have in general been designed to ensure the proper exploitation of hydrocarbon resources in a manner consistent with the "national interest" as defined by governments of the respective Coastal States. The safety of operations is only one amongst a number of considerations entering into the definition of the national or public interest. Indeed, the rationale for government involvement, either by way of direct participation or by way of regulation, is found in a broad mix of economic, social and political considerations that lie beyond the purview of this inquiry, considerations such as control of pricing, tax policy, royalty payments, or land use policy by the state acting as landlord. However dominant these considerations are in current discussions over the regulation of offshore hydrocarbon exploration and exploitation, they can be examined here only as they impinge on the issue of safety.

While it is possible, for example, to debate the relative merits of permitting free market forces to determine prices as against government-administered prices, the issue of safety is not open to debate. Indeed, it can be argued that the more the enterprise is left to the free play of competition in any unregulated market, the greater the pressure upon operators to reduce those "unproductive" elements of cost associated with the provision of adequate safety. In short, any sustained move to "deregulate" the industry should not be allowed to compromise the issue of safety, for as is said of war and generals, safety is too important to be left entirely to the industry. This is not, however, to argue that industry, accordingly, should be freed from the burden of ensuring safety of the enterprise. Quite the contrary; industry must be held fully accountable for that assurance, even as its invaluable expertise and knowledge should be regularly canvassed by the governments that carry the ultimate duty of defining and implementing the public interest in this critical area of public policy.

Indeed, it is to encourage amongst all participants in the offshore drilling enterprise a sense of responsibility for safety that governments see fit to impose controls. If this attitude of mindfulness could be generated naturally and be nurtured spontaneously in all participants, there would be no need of regulatory controls to ensure safety. But, whether it is the roustabout on the drilling rig allowing familiarity to breed carelessness; or the toolpusher allowing tight timetables to overcome dis-

cretion; or the operator with an eye to the costs entailed in delays for safety reasons; or the designer torn between what his expertise informs him is needed and what the actual minimum requirements demand: all have their reasons for ceasing to pay attention – for failures in responsibility, and, in some cases, even in accountability.

The issue of accountability is rendered more awkward to deal with because of the number of participants involved in a long chain of decisions that leads from the design of a MODU to its operation and the consequent diffusion and dilution of responsibility. It is for this reason that use of the term "the industry" to embrace all of those who have an active role and therefore share in the accountability for ensuring safety of the offshore operation conveys a misleading sense of a rather monolithic entity that has to be regulated and controlled. Not only does the large number of participants make it more difficult to get the accountability equation right, but also there is no continuum of responsibility extending from the designer of the rig through to the drilling contractor who owns it, to the operator who engages it, and to the auxiliary services, such as support vessels, helicopters, and meteorological forecasting. The relationships at each stage are governed by discrete contracts as between rig designers and drilling contractors, builders and drilling contractors, drilling contractors and operators, and operators and sundry suppliers and support service contractors. The fact that each set of participants bears some responsibility for ensuring safety along the way does not guarantee that, when men and machines are placed together in the operative mode offshore, all will coalesce to ensure safety. The fact also that the entire process of designing, constructing and operating drilling rigs is characterized by separate and disconnected contractual relationships is what makes it so important that the regulatory authority, through approval and safety audit procedures, ensures that the relevant participants have been attentive to safety requirements.

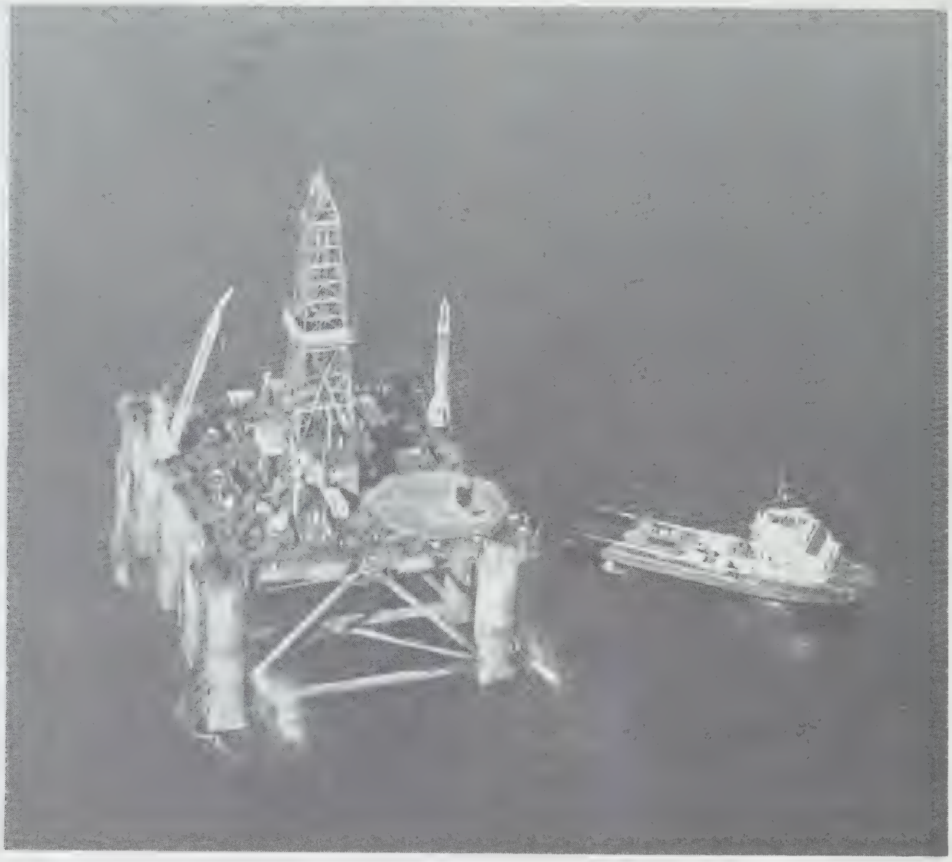
In the final analysis it is contractual relationships – the licence to drill – that provide the means by which government asserts its ultimate regulatory and controlling powers over the operation. It is also the means through which, in varying degrees of prescriptive detail, government seeks to encompass all aspects of the drilling operation. But, even the most intrusive government must realistically lean heavily on the expectation that, at each contractual point, sufficient attention has been paid to safety by the contracting participants themselves, regulated as much by their own professional and ethical prescriptive codes as by rules and standards imposed by government. Government regulators are driven to this posture because of the complexity and the number of stages in the enterprise where much has to be done on the basis of reposing faith in the professional and ethical codes of the various participants. This posture of trust is also attributable to the complexity and rapidity of change in the technology involved, where reliance on those with experience or specialized knowledge is called for and where the need to reproduce that same expertise within the governmental bureaucracy would result in unnecessary additional cost. The importance of the industry to the national economy and the fact that offshore drilling is conducted on an international basis provide government regulators with additional reasons for approaching their task in an accommodating and co-operative way.

This last element – the international dimension – emerges partly because of the multinational nature of the offshore drilling industry and partly because the enterprise is conducted offshore, where questions arise concerning the respective jurisdiction of the Coastal State and the jurisdiction exercised over the rig by the country whose flag it flies. Whereas there is a lengthy tradition of dealing with the issues of extra-territoriality of a nation's laws and jurisdictional writ as applied to vessels – all of which is complex and controversial in its own right – there is as yet not nearly as clear a jurisdictional line established for MODUs. At best, regulators confront two separate realms – the case of the elephant and the whale – the land-based tradition for oil drilling uneasily seeking to adapt to the long-standing marine regulatory tra-

10.1 Offshore exploration extends the technology of land-based drilling into the marine environment. The multinational nature of the offshore drilling industry brings it under the control of varied national regulatory regimes and international conventions.

dition. The jurisdictional problem is greater when, as in the case of Canada, one adds the further juridical complication of seeking to regulate offshore operations within the purview of a federally organized state, where powers are constitutionally divided between the two levels of government and where both the national government and the government of the relevant coastal province may have a joint but not necessarily collaborative stake in overseeing the management of the enterprise.

Before the state can exercise control over any activity beyond its territorial boundaries, its claim to do so must be recognized by the comity of nations. The right of a Coastal State to exercise jurisdiction over exploration for and exploitation of oil and gas on its continental shelf is based upon the *Convention on the Continental Shelf, Geneva, 1958.* Article II of that *Convention* provides that the Coastal State exercises sovereign rights over its continental shelf for the purpose of exploring it and of exploiting its natural resources and, as one writer has added, for no other purpose. This means that the Coastal State can apply to these activities the whole body of its domestic law and subject them to all rights, duties and obligations under the law as if they were conducted on land. That *Convention* only enables or confirms the exclusive right of the Coastal State to exercise its jurisdiction over those activities and prohibits other states from doing so without its consent. The law of the Coastal State does not become applicable automatically upon ratification of the *Convention.* In order for its laws to apply to offshore hydrocarbon exploration activities, it is necessary for the Coastal State to enact legislation declaring that its laws are applicable generally or, alternatively, declaring which of its laws are applicable. The right of the Coastal State, however, to extend its laws offshore is not unlimited. The State is sovereign within its territorial boundaries but on its continental shelf it exercises sovereign rights over limited activities – exploration for and exploitation of minerals. There are also certain other limitations but they are not relevant to this analysis.



10.2 Both Canada and Norway have established safety zone regulations which exceed those specified in the *Convention on the Continental Shelf, Geneva, 1958*. Safety zones around fixed and floating drilling rigs are intended to prevent collisions with, or interference from, other vessels transiting the area.

There is, however, one limitation that requires special consideration and that might be exceeded. Article V provides that the Coastal State may establish safety zones to a distance of 500 metres around offshore drilling installations except where interference may be caused in the use of recognized sea lanes essential to international navigation. The 500-metre safety zone, within which the Coastal State may prohibit the entry of ships, has been criticized as being inadequate to allow Coastal States to exercise the necessary degree of jurisdiction and control. It provides, for example, too little room for error because of the size and lack of manoeuvrability of many modern-day vessels. If the safety zone is measured from the installation itself, it will permit entry well within the anchoring pattern of rigs. Canada has incorporated the 500-metre rule in her regulations except for rigs that are moored with anchors. In these cases the safety zone extends 50 metres beyond the anchor pattern. In adopting this 50-metre rule, Canada, like Norway, has exceeded the limit specified in the *1958 Convention*. Neither the 500-metre zone from the installation nor the 50-metre zone from the anchoring pattern provides adequate protection to the installation. Canada should consider establishing the zone at least 500 metres from the perimeter of the anchoring pattern or, preferably, determining what an appropriate zone should be under the environmental conditions on the continental shelf and, like the United Kingdom, declare that zone to be an area of her jurisdiction. The enactment and enforcement of legislation preventing pollution in the waters of the northern archipelago is a precedent for Canada taking unilateral action and receiving international acceptance.

Many Coastal States that have ratified the *1958 Convention* have enacted legislation to extend the application of their laws to the offshore. The United States has enacted the *Outer Continental Shelf Lands Act*, the *Submerged Lands Acts* and other legislation for that purpose. The United Kingdom enacted the *Continental*

Shelf Act 1964 to provide the legal framework to facilitate offshore development, the *Mineral Workings (Offshore Installations) Act 1971* and other major pieces of legislation to exercise control over various aspects of the operations. Norway has also passed a *Continental Shelf Act 1963*, delegating authority to the King to give approval for exploration, drilling and exploitation of subsea petroleum resources and to establish the rules for the conduct of these activities. In Canada, as in the United States, Supreme Court decisions have confirmed the federal domain over oil and gas activities on the continental shelf. Canada elected to exercise her jurisdiction under the *Canada Oil and Gas Act*, and the *Oil and Gas Production and Conservation Act* and, to some extent, enforces compliance with her laws and her regulations through a permit process. No continental shelf act, however, has yet been enacted nor has legislative action yet been taken to extend the general application of Canadian law to offshore hydrocarbon exploration and exploitation activities.

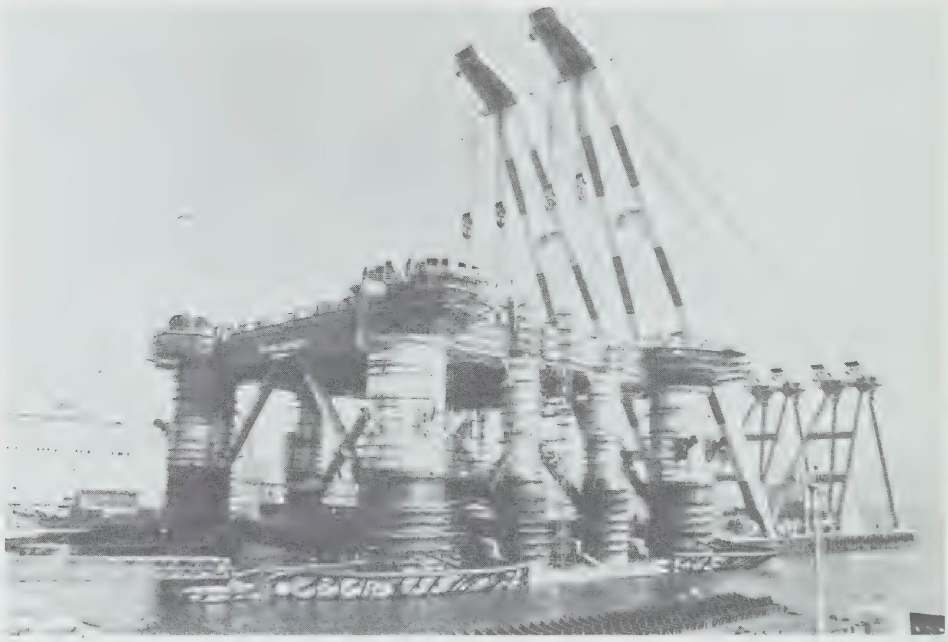
The reason for Canada's failure to follow other sovereign states and to pass a continental shelf act is a matter for conjecture. What has become evident is the need now for its enactment and the extension of the application of her laws to offshore drilling activities – in short the extension of appropriate federal and, by adoption, provincial law. The extension of Canadian law to the continental shelf will end some of the uncertainties that exist, such as the application of the Criminal Code to an owner of a drilling rig of non-Canadian registry, but it is not a panacea to end them all. What is needed is legislation designed for application to MODUs and to the varied aspects of their offshore operations including the standby role of vessels and the rescue role of helicopters under contract to the industry. This is a matter of enacting comprehensive legislation related to these operations or of amending existing legislation, but not of stretching it to fit a Procrustean bed, by defining, for example, a jack-up as a ship in order to bring it within the *Canada Shipping Act*.

Drilling rigs operate in the international market where the international maritime community, through several agencies, has developed minimum safety requirements for all vessels. The dominant intergovernmental agency is the International Maritime Organization (IMO), formerly the Intergovernmental Maritime Consultative Organization, established in 1958 as a specialized agency of the United Nations with membership drawn from most of the maritime nations of the world. IMO is designed to create order out of the medley of conflicting mandatory requirements of member states and to establish common standards for marine safety, pollution and navigation. The measures that it develops are eventually promulgated as conventions, for example, the *Safety of Life at Sea (SOLAS) Convention* and the *International Convention on Load Lines*. IMO has no legislative or regulatory power; its conventions come into force as and when they are ratified by member states. It also has no means of forcing its members to comply with its rules and conventions. Although during the prolonged discussions and negotiations that precede general agreement upon and adoption of new conventions, efforts are made to raise the level of standards under consideration, the end result is normally the adoption of minimum requirements which are, in fact, the maximum upon which agreement can be reached.

The first *IMO Code* for mobile offshore drilling units was adopted in 1980 and is currently under review. It constitutes a common base for the mandatory controls to be exercised by member states. It is incumbent upon members, including Canada, to support IMO in its efforts to improve the quality and to extend the range of its codes and conventions, though they may, while complying, increase the standards to meet their local needs and perceptions. This latter action Canada should take because of the environmental conditions on her continental shelf.

Active also on the international scene and in establishing international rules are the classification societies. The classification of vessels originated in England over 200 years ago in Lloyd's Coffee House where the most influential members of

10.3 The *Ocean Ranger* was constructed and classed in accordance with the American Bureau of Shipping's *1973 Rules for Building and Classing Mobile Offshore Drilling Units*, and retained its classification to the time of its loss.



the shipping trade in London would gather to discuss business. Underwriters called upon to accept maritime risks and shippers of valuable cargo came together to seek some guarantee of fitness of the vessel in prospect. There evolved a rough system of inspecting hulls and equipment and, on the basis of experience, rules were developed, which applied recognized standards. From this voluntary association evolved Lloyd's Register of Shipping, now an international, non-profit body. Similar organizations have developed in other maritime nations. The standards set by the different classification societies are similar and represent the cumulative experience acquired through extensive research and development and through surveys of thousands of ships over many years. In classing a vessel, the societies attest that it meets a standard of construction which assures adequate structural strength under the conditions for which it was designed, that its electrical and mechanical systems comply with acceptable standards and are properly installed, that the vessel is maintained by its owner to the extent that it complies with the rules and does not lose its classification, and finally that all major repairs or structural changes are carried out in accordance with the rules of that society.

"The American Bureau of Shipping is not responsible for the operation of the unit. It is incumbent upon the owner to provide instructions and to set limits on operations so that the loadings and environmental criteria upon which the classification is based are not exceeded. To this end, an Operating Booklet containing those instructions and limits should be provided aboard the unit. The Operating Booklet is not to be submitted for review."

Rules for Building and Classing Mobile Offshore Drilling Units. American Bureau of Shipping. 1980

Classification societies became involved in the offshore drilling industry in the early years when structures operated close to shore and had many of the features of conventional ships; they applied the rules that had evolved for these ships. But as new designs emerged and rigs operated farther from shore and under increasingly severe environmental conditions, new rules, specific to MODUs, became necessary. The American Bureau of Shipping (ABS) published the first set of MODU rules in 1968 and was followed by the other classification societies. Where MODU rules do not address a particular aspect of a rig, the rules for ships are applied. Where MODU rules exist, they are based on relatively short historical experience. In considering the role of the classification society in the regulatory process, it is tempting for one to lose sight of the original and primary role of classification societies, that is, to satisfy the owner and the insurers that a rig is designed and constructed, outfitted and maintained to a standard which is sufficient for the service and area of operation for which the rig is intended. This standard is considered to be achieved if the rig complies with their rules. Classification does not ensure seaworthiness since the management and operation of the rig, vital aspects of seaworthiness, are not examined by classification societies. As a spokesman for ABS pointed out during the Inquiry into

the loss of the *Ocean Ranger*, if others choose to give a wider meaning to classification than compliance with rules, they do so at their peril.

Many important areas pertaining to the safe operation of a rig, for example, navigation and communication systems, and evacuation systems, that are not covered in the rules of the classification societies, are the concern of the Flag State which has jurisdiction over all aspects of the rig and whose domestic law applies to it. It is for this reason that the owner of a rig ensures, during the design and construction stages, that the rig complies with the rules not only of the classification society but also of the Flag State that has been selected.

The Coastal State, however, can, under international law, set whatever requirements it decides upon for those who seek permission to drill on its continental shelf and can deny that permission and the use of its ports, unless compliance with its laws and regulations is assured by the operator. In areas where the Coastal State has not legislated, the requirements of the Flag State will have to be observed. Where the Coastal State does legislate, there is the possibility of conflict between the requirements of the Flag State and those of the Coastal State, the Flag State asserting its sovereign rights over the rig and the Coastal State maintaining its sovereign rights over the exploration and exploitation of its offshore mineral resources. Under these circumstances the will of the Coastal State must prevail, and, depending upon the nature of the conflict, the owner of the rig may, in the final analysis, have to change the state of registry of the rig or move it to a location in another jurisdiction.

Within the framework of international laws and conventions, every Coastal State in the exercise of its jurisdiction over offshore exploration must wrestle with the same central concern; the suitability of drilling rigs to operate safely under the environmental conditions that prevail on its continental shelf. This central concern will seek expression in each of the several areas that have been analysed in the foregoing chapters. It will entail requirements to ensure the integrity of the rig and its critical systems, its operability, its management, and its manning including the training, health and safety of its crew. There will also be involved measures to protect and safeguard the well and the environment, and means for evacuation and for rescue in the event of an emergency.

In the exercise of its responsibility to protect the national interest, the welfare of its citizens and the environment, each Coastal State will become involved with these substantive areas in varying degrees. The extent of state involvement will be a function of its legal traditions, the social and political philosophy underlying these evolving traditions and the current practices of government. It will depend, as well, upon the nature of the physical environment, the attitudes of its people, and the incidence of accidents or disasters offshore. A generalization based on current practice is that Canadians and Britons accept a greater degree of governmental interference or intervention in their economic affairs than do United States citizens but less than those of Norway. But all general statements, even this one, may be to some extent fallacious. Comparisons between states, because of their inherent differences in traditions and in popular expectations of government, may be misleading though, when exercised with care, they may be enlightening in seeking solution of common problems.

Pre-eminent among the common problems and contributing to them is the fact that the offshore exploratory oil industry is still relatively new and continues to operate at the frontier not only of technology and experience, but also of the law. Developments in technology in this new industry are spurred on by the ever-present search for more efficient modes of operation and by the need, imposed by reason of the marine environment, for greater security and safety. Here the elephant and the whale meet on the frontier where the land-based traditions of the petroleum industry strive with varying degrees of success to adapt to the traditional marine regulatory environment and where, to change the metaphor, the cowboy has to become to some

degree a sailor. Changing technology poses a distinct challenge to the legal system which tends in all countries to move at a slow, reluctant pace. The challenge for the regulatory regime in all states is to find, in the face of a rapidly changing technological environment, a means of ready adaptation in the legal system and an easy mode of change in mandatory requirements, while retaining the necessary degree of certainty. What the regulatory regime of a state should seek to achieve is a balance between controls that are flexible and responsive to the imperative of rapidly changing technology, and controls that possess certainty for the regulated interests. Stability is also required for those regulatory agencies vested with the responsibility for administering, monitoring and otherwise enforcing the rules. The balance between flexibility and certainty for each Coastal State differs, as do the instruments used for achieving that balance.

The instruments used by different countries to exercise control over offshore drilling activities range in authority from legislation to circular notices. They include statutes, regulations, guidance notes, and instructions. Not only do states vary in their use of this selected armoury of regulatory instruments but so also do they vary in the choice of the substantive areas in which they seek to deploy these instruments.

Because of the pressure on a legislature for time and because of the length of time generally required for their enactment, statutes tend to be used sparingly. States normally enact enabling legislation to express governmental objectives, the broad purposes of the legislation, the framework of administrative mechanisms and the authority devolved upon these mechanisms to exercise discretionary decision-making powers. The relative inflexibility of legislation, as a regulatory instrument, induces all governments to rely more on subordinate legislation, for example on orders and regulations, to put flesh on the bare skeleton of the general legislation. Compliance with this subordinate legislation is as mandatory as compliance with the enabling statutes which authorize the promulgation of orders and regulations. The particular governmental structure and practices of each state will determine not only the use of the instruments and the substantive areas of application but also the amount of detail contained in the regulations. Regulations may establish performance standards, accept by reference the standards of established external agencies or specify the equipment to be used or measures to be taken. Penalties in law may follow violation of regulations.

Other instruments used by government to exercise control are of an informal nature and are not mandatory. Such devices as guidance or operation notes are used to elucidate government policies, to interpret the relevant acceptable standards, to provide guidance to the operator, and to clarify what is expected of the operator. Instructions, circular notes and other informal devices are used to explain government policy and delineate anticipated response. While these instruments are non-mandatory, failure to comply may bring loss of the good will of the regulator, may increase the expense entailed in obtaining required permissions through lost time and even, in the last analysis, may lead to the abrogation of permits or refusal of an extension – drastic measures that are rarely, if ever, adopted.

An examination of the regulatory instruments used in the states under comparative review reveals variations in their types and in their application. In the United States, the prime instruments used by agencies and departments are regulations formulated and issued under authority of general legislation and subject to procedural requirements laid down in a general procedures statute, the *Administrative Procedures Act*. A more flexible instrument is the Executive Order which is not required to comply with the *Administrative Procedures Act*, although in recent years revisions to Executive Orders have tended to do so. Stipulations in leases, notices and circulars informing the industry what equipment and procedures will comply with regulations are other devices used. Perhaps the most important practice that has come into common use is that of incorporating in the regulations standards estab-

"Although the [United States] Coast Guard has not specifically defined the BAST process in regulations, the concept is inherent to our regulatory program. Our system of plan review, our requirements for safety equipment, and our inspections and investigations implement this process. New technologies are accommodated in our regulations by permitting substitutions of materials and procedures if the substitute provides an equivalent or better level of safety."

Capt. Thomas F. Tutwiler, Chief
U.S. Coast Guard Merchant Vessel Inspection Division
Proceedings from the Symposium on the Safety of Life Offshore, June, 1983

lished by external professional associations. This is accomplished through the Best Available and Safest Technology (BAST) requirement, a statutory mechanism that has become generally adopted in recent years. That mechanism is intended to enhance the adequacy of technologies and of regulations dealing with offshore safety. Where the BAST requirement is mandatory, it needs to be supported by a program of investigation that determines what technology is best and safest by a concerted program of research and development to improve existing technology and by a program of monitoring to ensure that the best and safest technology is, in fact, being used. The merit of this technique of control is that it meets the requirement of flexibility by encouraging and accommodating innovations. It meets the need of the operator for a balancing of certainty of application with the need of the regulator for flexibility to adopt emerging technologies and to adapt control to changing conditions. At the same time it vests discretion in the regulatory agencies to determine when an operator complies with the BAST requirement, but without obliging the regulator to establish specific standards.

In the United Kingdom, under the authority of enabling acts related to offshore oil and gas operations, subordinate legislation in the form of Orders in Council are issued on the authority of the Cabinet and departmental regulations on the authority of the Minister. Departmental regulations take less time both in formulation and in promulgation. Guidance Notes, Continental Shelf Operation Notices, Codes of Practice, and Notices to Mariners are devices used to give non-mandatory advice and even instructions to operators on methods of achieving objectives to an acceptable standard of reliability. Control of offshore oil operations in the United Kingdom is based upon the principle of self-regulation by industry and of effective monitoring by or on behalf of the regulatory agency. Regulations, both Orders in Council and departmental, state in general terms the standards to be observed and Guidance Notes are extensively used to provide the details. The need for continual revision of regulations to keep pace with technical changes has thus been reduced. The responsibility is placed fully upon the operator to ensure that acceptable standards and the requirements for safe operations are met.

In Norway, under the provisions of enabling legislation, Royal Decrees are issued, which provide the framework for the promulgation of detailed regulations, on the authority of ministers, to implement the Decrees. Ministers may then delegate the authority to regulate to agencies whose regulations are equally mandatory. As Norway has gained more knowledge of offshore oil operations, and particularly since the loss of the *Alexander L. Kielland*, the range of regulations has become more extensive to the degree that the oil industry is subjected to more regulations there than in any other country reviewed. As in the United Kingdom and in the United States, the Norwegian approach to safety is to make the operator responsible for ensuring that operations are conducted in accordance with safety regulations.

Norway, however, has a much more formalized procedure for ensuring that the operator is, indeed, responsible by requiring each operator to develop an "internal control system" covering his activities and the activities of all who work for him under contract. The operator must include in the contract provisions for ensuring compliance, not only with all mandatory requirements, but also with his own quality control and safety requirements which may well go beyond the minimum acceptable standard set forth in the mandatory requirement. The "internal control system" is designed to reduce risks through a conscious effort to incorporate safety and quality assurance into the planning, design, construction, and operational phases. Government guidelines have been issued, dealing with the arrangements by which an operator establishes an "internal control system". Once that system is submitted and accepted by the regulatory agencies, it is binding on both parties. There are indications that Norway, through this method, is beginning to decrease the range and the specificity of its regulatory control.

10.4 Exploratory drilling operations on Canada's East Coast are carried out under the regulatory control of the Canada Oil and Gas Lands Administration, which maintains regional offices in St. John's, Newfoundland and Halifax, Nova Scotia.

The nature of the Canadian regulatory mode in relation to the offshore is less evident, and apparently less developed, than that of the other jurisdictions under review. Canada has not enacted a continental shelf act and, therefore, her domestic laws lack general application to offshore drilling operations. Regulations, issued as Orders in Council under the authority of the *Oil and Gas Production and Conservation Act* have been rather modest in number and in the extent of their application. Regulations which are issued as Orders in Council are subjected to an unconscionably lengthy process which appears to be as inflexible as the statutes on which they are based.

Section 12.2(1) "The Chief Conservation Officer may in any particular case authorize the use of equipment methods, measures or standards that do not comply with the regulations where he is satisfied that such use provides a level of safety and pollution prevention at least equivalent to that provided by compliance with the regulation."

Oil and Gas Production and Conservation Act, amended 1981

The legislation gives unusually wide discretionary powers to the Chief Conservation Officer, the head of the primary regulatory agency, even to the extent of authorizing him to suspend or dispense with the application of existing regulations. The prime instrument of control is the application-permit system. Through it the regulatory agency in general, and the Chief Conservation Officer in particular not only implement policies relating to the design, construction and operation of rigs, but also seek to exact compliance with relevant laws. It is under this system that the Chief Conservation Officer exercises wide powers. Compliance with the provision of Canadian laws and regulations is made a condition of obtaining and retaining a drilling permit. In the exercise of these powers, guidelines are issued to interpret regulations, indeed, to stand in the place of regulations, to convey recommended practices and procedures and to explain policies and objectives. Instructions are also issued by word of mouth, telex, letter or other means. For these reasons it is difficult to discover what controls are, in fact, being enforced. Discussions may be held with an operator, and instructions given, which may differ with different operators or with the same operator on different occasions. Such an informal practice not only raises the possibility of differential treatment of various operators but also accentuates the discretionary and possibly, the arbitrary or capricious aspect of the regulatory process. The extent of the application of laws and regulations may be a matter of negotiation and even of trade-offs involving safety. Equivalency standards, for example, may be reduced under pressure for early production. The application of law and regulations becomes a private matter between the regulatory authority and the operator. Nor is there any realistic means of enforcing compliance when it is deemed to be necessary. The owner of a rig of foreign registry is not subject to the laws; thus the penalties relating to a breach of the law applied to the operator cannot, in practice, be applied to the owner of the rig. The regulatory agency has to resort to the withdrawal or threat of withdrawal of permits or to administrative penalties such as costly delays which may prove to be even more effective than threats. The deterrent of public prosecution and of its possible adverse publicity with consequent public criticism is missing. The extension of the full body of Canadian law to offshore drilling operations and the development of a body of regulatory controls in the public domain would remedy these defects.

It is apparent that there are many instruments employed by regulatory agencies in fulfilling their mandate in relation to the offshore. They range from the broad-brush enunciations of general policy or of general objectives to the imposition of detailed design, equipment and procedural requirements. It is difficult to make a valid generalization about any of the states under comparative review because of differences of approach in different subject areas. In the United States, regulations dealing with safety in the workplace range from general provisions requiring that the crew "perform all operations in a workmanlike manner" to very specific requirements as in well control. The United States Coast Guard issues detailed and comprehensive regulations prescribing training and experience for the certification of certain marine personnel, but imposes few regulations regarding manning standards for MODUs or training standards for industrial personnel or ballast control operators. Training is left to individual companies with the result that, as the National Academy of Science reported "regulations have been much more successful in ensuring the use of adequate technologies than in ensuring that workers, particularly entry level workers, are properly trained in safe practices." In other areas such as design of rigs, certification and installation of equipment for fire prevention and well control, the regulations are extremely detailed. Increased demand on United States Coast Guard inspection personnel, increasingly complex technologies and a current desire to minimize government involvement in the private sector appear to have resulted most recently in a greater use of voluntary standards and a greater involvement of classification and professional societies in the regulatory process.

10.5 The method of regulatory control over offshore drilling varies considerably between Coastal States. Canada, the United States, the United Kingdom and Norway have each established regulatory regimes which differ in content and in the manner of enforcement.

The British approach is one generally of stating performance standards in regulations and supplementing them with Guidance Notes and other non-mandatory instruments. With respect to design, construction and survey, all rigs must be certified as fit for the purpose specified. For well control, the operator is responsible for the avoidance of harmful methods of working and he is directed to execute all operations in a proper and workmanlike manner in accordance with methods and practice customarily used in good oilfield practice. More specific regulations pertain to workplace safety and to the training of certain key personnel. It is, however, the responsibility of the operator to ensure that rigs are properly manned with persons competent to perform the task for which they were engaged.

In the combination of broad objectives and specific requirements, the Norwegian approach is essentially the same as the others, though with a much greater emphasis upon specific requirements. The requirements for design and construction are detailed, specific and stringent. For well control they incorporate accepted oilfield practices, place responsibility squarely on the shoulders of the operator and issue specific requirements. There are numerous regulations regarding workplace safety, detailed regulations for training of key personnel and a requirement for basic marine training for all. Though their regulatory system is more extensive than most others, the Norwegians incorporate flexibility in their regulations to ensure that technical changes can be adopted in individual cases.

It is difficult, as stated earlier, to determine the essential nature of the Canadian approach to regulatory control behind the screen of the application-permit system. The Canadian system is the least developed of those that have been examined. Its comparative neglect of regulations, in contrast with stipulation in permit negotiations, however, provides ample opportunity for change and improvement. *Interim Standards* have been established for the design and construction of rigs. For safety in the workplace and for well control, numerous procedures and equipment that must be employed are specified. The only specific regulatory requirement for training is the stipulation that all rig supervisors, drilling foremen and toolpushers successfully complete a course in well control. The operator is, however, responsible to ensure that all employees receive instruction and training with respect to all operational and safety procedures that they might be required to perform. There are requirements

for drills on board but there is no regulation requiring basic marine training for the crew.

In exercising its controls, each jurisdiction examined accepts in principle the desirability of concentrating responsibility for safety on oil rigs in as few regulatory bodies as possible. In the United States, some 18 federal agencies have an active interest in some aspect of offshore operations and 6 agencies have statutory authority to regulate day-to-day activities. There are, however, two prime agencies: the Geological Survey in the Department of Interior with responsibility for regulating all mineral exploration, drilling and production operations on the continental shelf, and the United States Coast Guard in the Department of Transportation with responsibility for all aspects of maritime safety.

In contrast, in the United Kingdom, since the adoption of the Burgoyne Committee report on *Offshore Safety* in 1980, one agency, the Department of Energy, has full responsibility for all offshore safety matters except for ships and seafarers – that responsibility remains with the Board of Trade. The major control body in the Department of Energy has been strengthened through the transfer of inspectors from the Health and Safety Executive of the Health and Safety Commission. In Norway there are nine institutions involved with mobile rigs and five with fixed installations. There are, however, as in the United States, two prime agencies, but with a rather different allocation of responsibilities. The Petroleum Directorate in the Department of Oil and Energy has responsibility for fixed installations, both exploration and production, and for drilling equipment and diving on all offshore installations; the Maritime Directorate in the Department of Trade and Shipping has responsibility for mobile platforms, for rescue equipment and exercises on fixed platforms, and for all maritime matters.

In Canada there exists but one lead agency exercising jurisdiction offshore, COGLA, a unique organization in that its Administrator, the Chief Conservation Officer, is responsible to two ministers, the Minister of Energy, Mines and Resources and the Minister of Indian and Northern Affairs, whose authority over oil exploration and development is divided by the 60th parallel. As in other countries under review, COGLA draws upon the services of several other federal agencies, especially the Canadian Coast Guard, for the performance of its responsibilities. The *Atlantic Accord*, signed in February 1985, between the federal government and the provincial government of Newfoundland, envisages the early establishment of a single administrative agency to exercise jurisdiction over operations on the continental shelf off Newfoundland. The actual institutional arrangements and their impact upon COGLA and the Newfoundland and Labrador Petroleum Directorate at present remain nebulous.

Whatever organizational arrangement may evolve for eastern Canada, it is instructive to observe that in almost all jurisdictions under review – the exception is the United States – the trend has been markedly in favour of a lead agency, if not a "single window" for regulatory purposes. Norway, for example, has initiated the process of moving responsibility for regulating all exploratory activites to the Petroleum Directorate with a view to focusing responsibility for the safety of all aspects of the operations in a single agency. In the United Kingdom the adoption and, indeed, the acceptance within government circles of a single window approach was facilitated by the establishment by the Department of Energy, during the formative years of oil development, of an interdepartmental committee – the Offshore Installations Technical Advisory Committee (OFINTAC) consisting of recognized specialists drawn from government agencies. Its function was to provide the Department of Energy with a wider range of technical knowledge than was available in any one department, in order to develop the regulations for construction and survey and to consolidate the Guidance Notes for the so-called Blue Book. With these purposes achieved, the Committee has been disbanded. This is a device that Canada might well adopt. It is

important, however, to note, as did the Burgoyne Committee report on *Offshore Safety* when it endorsed the single window approach, that combining in one lead agency responsibility for regulating exploration, production and safety carries with it an attendant danger. There is the inherent risk that, in the drive for energy self-sufficiency under conditions of economic stress, the price to be paid may be to compromise safety. If, however, the risk is fully recognized and appropriate precautions taken, as, for example, the establishment of a Safety Branch within the single regulatory agency, the single window approach would appear to be the best institutional arrangement for regulating offshore oil operations. The concept is endorsed strongly by industry because of the reduction in regulatory duplication and conflict and because of the clearer lines of communication between the regulator and the regulated.

A device common to all jurisdictions under review, to ameliorate jurisdictional jealousies and administrative overlaps is the Memorandum of Understanding, negotiated between the lead agency and another department or agency. In the United States, for example, a Memorandum of Understanding has been negotiated between the United States Coast Guard and the Occupational Health and Safety Administration, whereby the United States Coast Guard is given major responsibility for safety in the workplace offshore. In similar fashion and for a similar purpose, the Department of Energy in the United Kingdom took over responsibility for health and safety inspection offshore from the Health and Safety Executive. While it is normal for the Memorandum of Understanding to be used as a device for enabling the lead agency to take on additional responsibilities in the regulation of offshore oil operations, its use in Canada has been somewhat different. The Memorandum of Understanding between COGLA and the Canadian Coast Guard, rather than transferring authority and responsibilities from the Coast Guard to COGLA, in fact empowers the Coast Guard, through delegation from COGLA, to undertake certain functions that would otherwise be outside their jurisdiction. The legal necessity for this transfer of powers to the Coast Guard through a Memorandum of Understanding stems from the fact that, as mentioned above, the *Canada Shipping Act* does not yet apply to rigs of other than Canadian registry that are engaged in drilling operations on the continental shelf. Without application of the *Canada Shipping Act* to rigs of foreign registry, the only way its provisions can be applied by the Coast Guard is by virtue of delegation of powers from COGLA, powers which COGLA obtains from its *Oil and Gas Production and Conservation Act*.

Whatever organizational structure may be adopted, the major roles of the regulatory agency responsible for offshore safety are the formulation of policy and the promulgation and enforcement of regulations designed to give effect to that policy. The complex and highly technical nature of the operations makes it a practical, if not a legal, necessity for industry to participate in that process. For the regulatory agency to be able to act unilaterally in the drafting of regulations and even guidance notes, it would require not only a large infrastructure but also an intimate and extensive knowledge of technical requirements. Industry, for its part, is obliged to keep abreast of advancing technology and, in certain areas such as industrial training, will know best what standard is required for competent performance. Industry's participation, however, in key elements of the regulatory process varies from one country to another and from one area to another area in the same jurisdiction.

It is generally recognized that, because of the complex and changing nature of the technology or because of recognized experience, knowledge and interest of the industry or external professional bodies, certain aspects of the offshore industry should be left to industry to set the standards, subject to the acceptance and monitoring of these standards by the regulatory authority. In the jurisdictions examined, the provision for government to undertake consultation with industry is formally required by law. In the United States, the formal process of consultation is provided

10.6 A careful balance must be sought in the mode of regulation to ensure that human safety is not compromised by national goals for energy self-sufficiency or economic gain.

in the general enactment that applies to all regulatory bodies – the *Administrative Procedures Act*. Under this *Act* all proposed regulations are required to be published in the *Federal Register*, before they are promulgated in the *Code of Federal Regulations*. This provision permits the public and the industry the opportunity to comment before the regulations become final. Executive Orders are not required to follow that process. In addition to the formal requirements, other means are afforded to industry to comment informally on proposed regulations.

In the United Kingdom, there is a statutory requirement that "before making regulations. . .the Secretary of State shall consult with organizations in the United Kingdom appearing to him to be representative of those persons who will be affected by the regulations." With the emphasis in that country on self-regulation, the consultation between government and industry in drafting both regulations and Guidance Notes assumes increasing importance and has become an integral part of the regulatory process. Consultation is directed towards establishing practical standards for offshore operations and towards giving clarity to governmental objectives. Formal opportunities for input from industry are provided through statutory boards and committees like the Offshore Petroleum Industry Training Board with membership drawn from industry and training institutions and the Oil Industry Advisory Committee with membership from industry and workers to advise the Health and Safety Executive. The main channel of consultation is the United Kingdom Offshore Operators Association (UKOOA) which with its extensive committee system has a significant role through prior consultation in the development of the Guidance Notes issued and amended by the regulatory agency. UKOOA also prepares preliminary drafts of technical regulations for submission to the regulatory agency. In areas where responsibility for standards is left to industry, for example, in training and in health it establishes for its members non-mandatory guidelines which are accepted and monitored by the regulatory agency. In Norway preliminary informal discussions regarding a proposed regulation take place with recognized experts, drilling contractors and others; after approval of the intent of the regulation by government, formal hearings

are held. Before approval is given, the revised proposal in its final form is sent out to interested parties for review.

In Canada, there is no statutory requirement for consultation with industry during the preparation of regulations and guidelines but informal discussions and consultation do take place and efforts are made to obtain the concurrence of industry with new regulations and their advice on standards of performance. Throughout the application-permit process there are opportunities for discussions and even negotiations between the regulator and the operator. In recent years and particularly since the loss of the *Ocean Ranger*, joint committees have been established, with membership drawn from the operators and in some cases from both levels of government. The Joint Government-Industry Offshore Training Committee has been set up to consider training requirements, curricula and standards; a Medical Advisory Group on Offshore Health to advise on matters of occupational health and safety and a Canada Lands Safety Advisory Council, with COGLA and industry providing co-chairmen, to address safety issues and concerns. The effectiveness of this relatively new and cumbersome committee structure as a forum for meaningful consultation and a source of effective action has been questioned. The Eastcoast Petroleum Operators Association (EPOA), now the Offshore Operators Division of the Canadian Petroleum Association, established a task force to study in depth various aspects of safety offshore and to make recommendations for action to its members. More recently it has initiated recommendations for training standards for personnel on MODUs which, if adopted by its members and accepted by the regulatory authority, will have the effect of non-mandatory guidelines.

The offshore oil industry, however, is more than the operating oil companies; it includes also a complex of service companies under contract to operators. These service companies have their own associations and their argument cannot reasonably be denied that, when matters affecting their direct interests are being negotiated between the regulator and the operator, they should participate. No provision exists for discussions between COGLA and the offshore drilling contractors or the owners of the supply vessels, although they have discussions with the Coast Guard on marine safety matters.

It is axiomatic that the compliance of the offshore oil industry with rules and regulations pertaining to safety will be enhanced, the more that it is provided with opportunities to participate in the formulation of regulatory requirements. The mode of ensuring compliance with rules and regulations depends upon the objectives of the regulator, the specific nature of the regulation and the responsibility and accountability of the operator or service contractor. It will depend upon whether the objective is to monitor or to police, to seek assurance of suitability for safety or to assess blame, to ensure strict adherence to the law or to develop sensitive attitudes and shared responsibility for safety. The mode of ensuring compliance also depends upon the subject matter and whether the regulations are specific and detailed, or general and based upon acceptable standards.

Where regulations are detailed and specific, the inspector needs to do little more than complete a check list, a role for which limited special knowledge or experience is required. Where, however, recognized performance standards are called for or particularly where standards are unspecified but, as at present in Canada, must be acceptable to the head of the agency, a much higher level of knowledge, of experience and judgment is required. In a country with a nascent offshore oil industry, there is a distinct shortage of persons who are qualified to exercise these functions and, when they acquire knowledge and experience, they are attracted into the oil industry where remuneration is less restrictive. It is, therefore, not uncommon to engage external agencies, like classification societies, as certifying agents to give assurance that regulatory requirements are being met. This practice has been adopted in the United Kingdom to certify that rigs are structurally suitable for operating

in the North Sea. A similar practice has been suggested for adoption in Canada, a safety audit to be conducted upon all rigs that operate on the continental shelf, to determine their structural and operational suitability. Where matters affecting safety during operations have been left largely to industry, the response has varied from Norway's insistence upon its "internal control system" to the application of BAST in the United States, or to UKOOA-determined guidelines in the United Kingdom. The involvement of the government's regulatory agency is one of monitoring the results, recording significant events and assembling a data base for future action and future controls.

In the final analysis government agencies formally enforce compliance by the use of penalties ranging from cancellation of permits or stoppage of drilling to fines. In countries where the laws of the land have been extended offshore, the full range of legal penalties and the consequent embarrassment of adverse publicity apply. In Canada, where extension of the laws offshore has not yet taken place, when formal enforcement procedures have to be invoked, recourse must be had to the *Oil and Gas Production and Conservation Act*. But in that *Act* offences are few and the most effective penalties are administrative, imposed on the authority of the Chief Conservation Officer. This arrangement, as mentioned earlier, reposes undue discretionary power on one statutory official – not the minister but the Chief Conservation Officer – thereby opening the door to bilateral negotiations between the operator and the regulator. It places reliance on the provisions of the permit to compel compliance and provides no graduated scheme of penalties but only one "sledge hammer" penalty in the event of failure on the part of operators to meet their obligations – namely suspension or a cancellation of the permit. The draconian nature of this inflexible penalty means, in practice, that it will seldom be used, giving rise in turn to the prospect of informal unpublicized arrangements between the regulator and the operator that accentuate, once again, the discretionary powers of the regulator.

Whatever the mode and extent of mandatory controls adopted and whatever the mode of enforcement considered advisable and feasible, the fundamental basis for safety offshore lies in the cultivation, in all those who participate, of a conscious recognition of responsibility and of the promotion throughout the industry of enforceable accountability following the development and adoption of policies and of a regulatory regime appropriate to eastern Canada's offshore. In that development process, Canada should remain alert to the prospect of drawing upon and wisely adapting to its special needs the growing body of knowledge, experience and practice of other nations engaged in offshore oil and gas activities, both in the North Sea and elsewhere.

11

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER ELEVEN CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

Part One of the Terms of Reference of the Royal Commission directed it to inquire into, report upon, and make recommendations with respect to matters directly relating to the *Ocean Ranger* and its loss. The results of that portion of the inquiry and the sixty-six recommendations arising from it are set forth in Report One. They are also included in Appendix B of this report, together with the response of the federal government to them.

2. "Inquire into, report upon and make recommendations with respect to both the marine and drilling aspects of practices and procedures in respect of offshore drilling operations on the Continental Shelf off Newfoundland and Labrador and . . . to the extent necessary and relevant, such practices and procedures in other eastern Canada offshore drilling operations."

Part Two of the Terms of Reference directs the Royal Commission to inquire into, report upon and make recommendations with respect to offshore drilling operations on the continental shelf off eastern Canada.[1] Against the background of the loss of the *Ocean Ranger*, the central concern of the Royal Commission has been to identify practical means of enhancing human safety in exploratory drilling off eastern Canada and that is the subject of this second and final report. Drilling operations there, are, at present, concerned with exploration and with the delineation of geological structures that have promise for hydrocarbon reserves. Development and production of the resources identified will change the nature and scale of those operations and introduce different factors and new risks. Nevertheless, many activities in the exploration and production stages are common, as are the principles governing the safety of operations and the risks to be encountered. The preceding chapters contain the analysis of the main issues affecting offshore safety and the rationale for the conclusions and recommendations that follow.

It is apparent that the hostile nature of the marine environment particularly on the Grand Banks and northward leaves no room for complacency. Fog, frequent storms, ocean currents, severe icing, icebergs, bergy bits, growlers, and pack ice combine to present the offshore drilling industry with what may be the greatest environmental challenge that it has yet faced anywhere in the world. What is needed is reliable information about the physical environment, advance warning of environmental hazards and a co-ordinated system to manage environmental data to meet the needs of both operators and regulators. What is needed even more is a method of assurance that rigs operating offshore are fully capable of meeting these environmental extremes. But the safety of a rig depends not only upon the quality of its structure and of its critical systems but also upon the quality of its management and the training and competence of its crew. It is also apparent that no evacuation system yet devised can, from a rig, cope with the raging seas of the Northwest Atlantic or the North Sea, nor does there yet exist a rescue system that is effective during a combi-

[1]All references in this Chapter to the offshore will indicate the continental shelf off eastern Canada.

nation of emergency situations of which a storm is one. Different means of regulation are adopted by nations reflecting their own constitutional structures and regulatory traditions. The regulatory regimen controlling offshore drilling operations must be firmly based on legislation, on mandatory regulations to the extent deemed necessary, but also on guidance notes to maintain essential flexibility. Its purpose is to provide the criteria against which performance can be measured and to ensure the accountability of those responsible. The issues raised in these chapters are addressed in the recommendations that follow.

The 70 recommendations contained in Report Two are numbered from 67 to 136, thus continuing in sequence from the 66 recommendations presented in Report One. The page reference given after the recommendation refers to the relevant section of Report Two.

ENVIRONMENTAL FACTORS

Detailed and accurate information about the environmental conditions under which drilling rigs will be expected to operate is essential for those who design and build them and also for those who maintain and operate them. Information on ice, waves and wind in the Northwest Atlantic is required, as also is knowledge of how these complex elements interact and the extremes that they may attain. Industry must know with some degree of precision what environmental conditions are to be anticipated in a particular drilling area, if rigs are to be designed or chartered to meet these conditions. Forecast procedures must also be so developed that accurate warning of approaching environmental hazards, which may require timely precautionary measures, is given to those in charge of operations. Some areas of offshore oil exploration, such as the North Sea, have been subjected to years of sedulous environmental mapping and the data required for analysis and estimation of normal and extreme conditions are relatively well documented and readily available. The region off eastern Canada is more isolated; the data are comparatively sparse and not always reliable, and prediction, particularly of the path of an iceberg, is uncertain. Uncertain, too, are the permutations and combinations of wind, waves, fog, and ice that leave little room for error in the performance of men and equipment. The characterization of environmental conditions is hampered, in some cases, by a technological gap in the capability of detecting, measuring and recording environmental phenomena. There is also no co-ordinated capability of interconnecting and standardizing available archive systems. It is the responsibility of the regulatory authority to know and to make known these conditions and of the drilling contractor who owns the rig and of the operator who seeks the permit to drill to be assured that the rig can cope safely with these conditions. It is therefore recommended:

67. That the regulatory authority document and publish a description of normal and extreme environmental conditions for the several offshore regions where drilling is being conducted or proposed. *(p. 32-33)*

68. That the collection of wave and climate data by government agencies be expanded in order that more adequate marine and atmospheric climatologies be developed for the offshore. *(p. 28-30)*

69. That government agencies in co-operation with industry:

(a) investigate the nature and effects of the interaction of wind, waves and currents at selected offshore sites; *(p. 30)*

(b) extend existing hindcast and the Canadian Forces Meteorological and Oceanographic Centre (METOC) based studies, exploiting fully the available data base to provide better coverage of the wave climate; *(p. 29-30)*

(c) develop wave models capable of dealing with the effects of shallow water and strong currents. *(p. 30)*

70. That government agencies accelerate research and development to improve the capability of equipment used for measurement of the characteristics of the wind and waves in the open sea. *(p. 30)*

71. That a co-ordinated archival and retrieval system of oceanographic and meteorological data be developed by government and industry. *(p. 32-33)*

72. That because of the large area for which environmental information is required and the great potential for contributions from the technology of remote sensing, consideration be given to accelerating the RADARSAT program and developing its capabilities to meet the needs of offshore exploration activities. *(p. 31)*

73. That the accuracy of forecasts of weather and sea states, especially beyond 48 hours and for mesoscale phenomena, be improved through:

(a) research into the physics of mesoscale phenomena; *(p. 32)*

(b) an expansion of the program for collecting real-time observation data; *(p. 31)*

(c) a re-assessment of the data required to be collected by industry and of the locations where the data is collected; *(p. 31)*

(d) a requirement for private forecasting companies to conduct forecast verification in a manner consistent and comparable with that of the Atmospheric Environment Service (AES). *(p. 32)*

74. That the mode of forecast presentation to those on the rig and the training of operations personnel in the interpretation of the forecasted weather and sea state be improved. *(p. 32)*

A critical feature of "ice management" is the surveillance system to provide early warning. Growlers and bergy bits are difficult to detect under certain weather conditions; their motions during high sea states are unknown as are the forces generated and the potential damage of impact. It is therefore recommended:

75. That industry and government agencies:

(a) accelerate their efforts to improve the capability of detecting icebergs; *(p. 26)*

(b) develop more reliable methods of predicting their speed and direction; *(p. 27)*

(c) increase research into equipment and techniques for changing trajectories of icebergs;

(d) undertake research into the impact of ice, especially growlers and bergy bits, upon MODUs. *(p. 27, 47)*

Icing can create hazardous working conditions on exposed surfaces and can hamper the operation of support vessels, fast rescue craft and evacuation systems. If severe, it may reduce the stability of the drilling rig. It is therefore recommended:

76. That research be undertaken into the physics and climatology of icing and into the development of methods for forecasting its severity and monitoring its accretion. *(p. 27-28)*

Adequate knowledge of the sea floor and subfloor is essential in order to determine whether "punch-through" or other problems exist at the drill site for jack-up drilling rigs. It has been the practice to take borehole samples before locating a jack-up and that procedure has been included in a "Notice to Operators". To endorse this proposal, it is recommended:

77. That before locating a jack-up drilling rig, the operator be required to make a borehole sampling survey of the proposed site. *(p. 30-31)*

REGULATORY CONTROL

The *Convention on the Continental Shelf, Geneva, 1958* recognized the jurisdiction of a Coastal State over mineral exploration and exploitation on its continental shelf and, in exercise of that jurisdiction, the United States, the United Kingdom and Norway have each enacted a Continental Shelf Act. They also passed legislation to extend their domestic law to these offshore activities. Canada ratified the *1958 Continental Shelf Convention* in 1974 but has not yet enacted a continental shelf act. To regulate exploration and exploitation of hydrocarbon resources on its continental shelf and to subject these activities to all rights, duties and obligations under the law as if they were conducted on land, a state needs to extend its domestic law to these activities. Canada has an additional juridical complication in that regard in that, under her constitution, both federal and provincial legislatures have specific and exclusive legislative powers. It is recommended:

> **78.** That early action be taken to enact a continental shelf act and/or other necessary legislation to extend the application of appropriate Canadian law, federal and, by adoption, provincial, to offshore oil and gas activities. *(p. 131, 136)*

Although Canada has ratified the *1958 Continental Shelf Convention*, there is one limitation imposed by it that requires special consideration. Article V provides that the Coastal State may establish safety zones to a distance of 500 metres around offshore drilling installations, except where interference may be caused in essential recognized sea lanes. Canada has incorporated the 500-metre rule in her regulations except for rigs moored by anchors. In these cases the safety zone has been defined to be 50 metres beyond the anchor pattern. In adopting the 50-metre rule, Canada, like Norway, has exceeded the *Convention*. Neither zone is adequate because of the size, speed and lack of manoeuvrability of many modern vessels. Canada should determine what the zone should be under the environmental conditions offshore and, like the United Kingdom, declare that zone to be an area of her jurisdiction. The enactment and enforcement of legislation preventing pollution in the waters of her northern archipelago is a precedent for her taking such an action. It is recommended:

> **79.** That Canada establish the safety zone to be of at least 500 metres outward from the perimeter of the anchoring pattern of moored drilling rigs or, preferably, determine what an appropriate safety zone should be under the environmental and other conditions of the Northwest Atlantic and declare it to be an area of her jurisdiction. *(p. 130)*

The extension of Canadian law to the continental shelf will end some of the uncertainties that exist, such as the application of the Criminal Code to an owner of a drilling rig of non-Canadian registry, but it is not a panacea to end them all. Where existing laws are deficient for the regulation of offshore drilling activities, extending their application offshore will not improve the legal framework within which the industry operates. The *Canada Shipping Act*, for example, and the regulations made under its authority are designed for conventional ships and not for semi-submersibles and jack-ups. It is not appropriate to stretch the application of existing law to drilling rigs by defining a jack-up rig, for example, to be a ship. What is really needed is the recognition, as classification societies of necessity have done, of semi-submersibles and jack-ups as *sui generis* and the enactment of a comprehensive statute specifically related to them and to the varied aspects of offshore drilling including the standby role of vessels and the rescue role of the helicopters under contract to the industry. It is therefore recommended:

80. That there be enacted an omnibus act specific to MODUs, and to the varied aspects of their drilling operations, including the standby role of vessels and the rescue role of the helicopters under contract to the industry. *(p. 131)*

One of the basic purposes of the regulatory process is to provide a framework within which the offshore industry can function with full and timely knowledge of the rules applicable at any given time. The nature of the Canadian mode of regulating the offshore is less developed than that of other jurisdictions examined. Without the extension of her general body of laws offshore, Canada has relied primarily upon the *Oil and Gas Production and Conservation Act* which is as applicable offshore as on land. Regulations issued under that statute have been rather modest in number and in the extent of their application. The drafting and promulgation of regulations are subjected to an unconscionably lengthy process with a consequent loss of flexibility. The prime instrument of control has been the application-permit process and stipulations in that process are being used instead of regulations and guidance notes. Indeed, instructions are often issued by word of mouth, telex, letter or other means. It is consequently difficult for industry to discover what controls are, in fact, being enforced. The application of law and regulations becomes a private matter between the regulator and the operator. An operator needs to know clearly the requirements which he and the other operators are expected to observe. These requirements, expressed primarily in regulations and explanatory guidance notes, need to be flexible to be responsive to changing technology but also to possess the level of certainty required by those who are regulated. It is therefore recommended:

81. That
(a) more extensive regulations and guidance notes be developed. *(p. 136-137)*
(b) insofar as it is practical, regulations be framed in terms of principles, performance standards and criteria, which, supplemented with a comprehensive body of guidance notes, are made available in a consolidated form. *(p. 134)*

A small committee of approximately twelve members selected by reason of their expert knowledge from other government agencies would provide technical knowledge beyond the capability of any one department to the single regulatory agency recommended in Recommendation 86. It is recommended:

82. That an intergovernmental technical advisory committee be established, consisting of recognized specialists from government departments and agencies, to assist in the formulation of the regulations and guidance notes referred to in Recommendation 81. *(p. 139)*

It is highly desirable that industry participate in the formulation of regulations and guidelines because of the complex, changing and often highly technical nature of the subject matter and because of the recognized experience, knowledge and interest of industry. If the regulatory agency were to be capable of unilaterally drafting regulatory instruments, it would need a large infrastructure with an intimate and extensive knowledge of technical requirements. It is axiomatic that the compliance of industry with rules and regulations will be enhanced through participation in the formulation of regulatory instruments. The offshore industry, however, is more than the operating oil companies; it embraces a complex of service companies under contract to the operators. These service companies have their own associations and their arguments cannot reasonably be denied that, when matters affecting their direct interests are being negotiated between the regulator and the operator, they should participate. Canada, alone of the countries under review, has no statutory requirement for consultation with industry, though in recent years informal discussions have taken place

and efforts have been made to obtain the concurrence of industry with new regulations and their advice on new standards. It is recommended:

> **83.** That in the formulation of the regulations and guidance notes mentioned in Recommendation 81, the regulatory agency be required by statute to consult regularly with the associations of those affected by the regulatory requirements. *(p. 140-142)*

It is generally recognized that there are certain areas such as industrial training where industry will know best what standard is necessary for competent performance or where standards determined by external agencies are the best to be adopted. Where the practice of utilizing external standards is followed, the association of operating companies develops guidelines for its members and the regulatory agency accepts and monitors them. It is therefore recommended:

> **84.** That where industry associations have the recognized knowledge, interest and commitment, their guidelines setting forth standards to be observed by their members be reviewed, accepted and monitored by the regulatory agency. *(p. 140, 142)*

Since MODUs operate in an international market, international rules and conventions have evolved. The International Maritime Organization (IMO) endeavours to create order out of a medley of conflicting requirements of member states and to establish common standards for marine safety, pollution and navigation. Canada should continue vigorously to support IMO. But IMO has no legislative or regulatory power. Its conventions and its codes, which are the product of prolonged negotiations, are the maximum requirement upon which agreement can be reached, though in fact they may be regarded by an individual state as a minimum base for its control system. It is recommended:

> **85.** That Canada, in developing its regulatory requirements, endorse and comply with the International Maritime Organization's *Code for the Construction and Equipment of Mobile Offshore Drilling Units* but supplement it with new or revised requirements to meet her needs and draw upon and adapt to her needs the research and experience of other states. *(p. 49)*

In the formulation of policies for offshore oil operations, in the devising of regulatory instruments and in the enforcement of control, each state under comparative review accepts in principle the desirability of concentrating responsibility for safety in as few regulatory bodies as possible. What organizational structure will evolve for eastern Canada after the signing of the *Atlantic Accord* and after the recommended extension of Canadian domestic law to offshore oil operations is yet unknown. It is instructive to note, however, the general trend towards a lead agency, if not a "single window", for regulatory purposes. The United Kingdom has adopted the single agency approach in allocating full responsibility to the Department of Energy, and Norway has initiated the process of moving full responsibility to the Petroleum Directorate. In this way competing jurisdictions, administrative overlaps and lack of co-ordinated, consistent policy are diminished. In Canada the principle of a single window approach was adopted with the establishment of the Canada Oil and Gas Lands Administration (COGLA). It is recommended:

> **86.** That Canada maintain the approach of a single regulatory agency, in concept and in practice, in exercising regulatory control over MODUs and the varied aspects of their drilling operations including the standby role of vessels and the rescue role of helicopters under contract to industry. *(p. 131, 139-140)*

A device common to all jurisdictions under review to ameliorate jurisdictional jealousies, administrative overlaps and lack of co-ordination is the Memorandum of Understanding negotiated between the lead agency or single window agency and another department or agency. Through this device, authority, responsibility and, in some cases, personnel are transferred to the single regulatory agency as, for example, in the United Kingdom, responsibility for health and safety inspection offshore was transferred to the Department of Energy. In Canada, the Memorandum of Understanding has been used for transferring powers in the reverse direction, as, for example, the empowering of the Canadian Coast Guard, through delegation from COGLA, to undertake certain functions that would otherwise be outside their jurisdiction. It is suggested that this practice be reversed. If the single regulatory agency referred to in Recommendation 86 is to have the authority and capability to exercise fully the responsibilities envisaged for it in Recommendation 80, then powers, and in some cases personnel, will need to be transferred to it. It is recommended:

> **87.** That powers and, where necessary, personnel be transferred by Memoranda of Understanding to the single regulatory agency from other line departments and government agencies so that it can exercise fully and effectively its responsibility for safety of MODUs and the varied aspects of their drilling operations including the standby role of vessels and the rescue role of helicopters under contract to industry. *(p. 140)*

The combination of responsibility in a single agency for regulating both the production of oil and gas and the safety of operations has the inherent risk that, in the drive for energy self-sufficiency, particularly under conditions of economic stress, the price to be paid for accelerated production may be a lowered level of safety. What is required within the single agency to offset this risk is a distinct, co-equal branch under a senior manager, responsible, *inter alia*, for the collection and analysis of safety data, for the formulation of safety standards and for the approving and monitoring of safety standards related to offshore oil operations. It is recommended:

> **88.** That a Safety Branch of co-equal status and under a senior manager be established within the single regulatory agency with responsibility, *inter alia*, for the development, application and monitoring of safety standards and for the analysis of safety data. *(p. 140)*

Accurate and timely data are essential to the formulation and implementation of any sound regulatory policy. Any significant event, including the failure of a safety system from which there is a lesson to be learned, should be accurately and promptly reported, carefully analysed and information about it disseminated throughout the industry.

In Report One it was recommended that information on the occurrences of significant events as defined by the appropriate regulatory authority be collected, systematically analysed and disseminated and that the definition of what constitutes a significant event be more adequately defined by the regulatory authority in consultation with industry.

Current regulations require the immediate reporting of such significant events as loss of life, a missing person, or serious injury to a person, and operators are "urged to advise COGLA of action to be taken to prevent such incidents from recurring." Efforts are being made, in consultation with industry, to define more specifically what constitutes a significant event but the definition remains vague and imprecise. It is recommended:

> **89.** That the information regarding significant events and all other information pertaining to human safety be standardized, the information be collected, collated and analysed by the proposed Safety Branch, and the results be disseminated to industry. *(p. 66-67)*

2.(a) "Inquire into, report upon and make recommendations with respect to the design, construction and stability of offshore drilling units and their suitability to conduct marine and drilling operations."

The fundamental question facing the regulatory authority pertaining to the safety of drilling operations on the continental shelf off eastern Canada is the suitability of the proposed drilling rig to operate under the complex environmental conditions that prevail there. The suitability of a rig for operations off eastern Canada will depend upon many variables. They centre around the physical integrity of the rig, the operability of its critical systems, and the quality of the management and of the crew. All three focal areas need to be investigated but there is also a need for an overall assessment of the rig as an operating entity, the soundness and stability of the structure, and the smooth integration of its systems.

At present all drilling rigs operating offshore are required to comply with the *Interim Standards Respecting Mobile Offshore Drilling Units* and the provisions of the *Canada Oil and Gas Drilling Regulations*. The assessment against the *Interim Standards* is performed by the Canadian Coast Guard who issue a Letter of Compliance, and against the *Drilling Regulations*, by COGLA who issue the Permit to Drill. The emphasis in both cases is upon the physical integrity of the rig. In the United Kingdom the assessment of the rig against the requirements of the Department of Energy has been performed in all instances to date by a classification society which issues a *Certificate of Fitness*. The classification societies are ideally suited for this responsibility by reason of their long experience with floating structures, their storehouse of statistical data and their extensive research facilities. But in the United Kingdom also, the certification process is limited to the physical integrity of the rig.

What is needed for an overall assessment of the suitability of a rig is a formal safety audit or approval process to assess and report on the physical integrity and stability of the rig, the operability of its critical systems, the procedures governing their operations and the rig, and the qualifications and competence of the crew to operate it safely.

Since the owner needs a reasonable assurance that his rig would be permitted to operate on the Canadian Continental Shelf, the major portion of the assessment of the rig should be undertaken before it is committed to a drilling program there. That portion should include an assessment of its physical integrity, performed preferably by a classification society. That assessment, together with supporting documentation, would be made available for examination by a safety audit team of qualified and experienced persons selected by the owner but approved by the regulatory authority. The safety audit team would also review critically, *inter alia*, all operational documents of the rig, the operational and emergency procedures manual, the operational history of inspections and modifications, the preventive maintenance program and maintenance logs, the crew training program, the personnel qualification requirements and administrative procedures. They would also review critical systems individually and as an integrated system. An inspection of the rig, interviews with members of the crew and consultation with the owner would follow. A report would then be made to the owner and to the regulatory authority, identifying any feature which might preclude or unduly inhibit the safe operation of the rig under foreseeable circumstances and recommending any necessary remedial action. The latter portion of the audit would take place after the rig is on the Canadian Continental Shelf to confirm that any deficiencies previously noted had been remedied and to give assurance that approved procedures are being followed by a competent, qualified crew. Upon receipt of a favourable report from the safety audit team, approval would be given by the regulatory authority. It is therefore recommended:

> **90.** That in addition to any specific requirements deemed necessary, the regulatory authority establish performance standards as recommended in Recommendation 81 against which the operational safety of drilling rigs can be assessed. *(p. 49-53)*

91. That

(a) the assessment be carried out by way of a safety audit or approval process consisting of three phases: (1) an assessment of the physical integrity and stability of the rig, (2) an evaluation of the operability of its critical systems and their interrelationships, and (3) an assessment of the qualifications and competence of the crew.

(b) phase one of the safety audit or approval process, namely an assessment of the physical integrity and stability of the rig, be carried out preferably by a classification society.

(c) phases two and three of the safety audit or approval process, namely an evaluation of the operability of the critical systems of the rig and of the competence of its crew, be conducted by experienced, qualified persons appointed by the owner of the rig and approved by the regulatory authority.

(d) the assessment of the physical integrity and stability of the rig and evaluation of the critical systems, their operability and integration take place before the commencement of drilling operations in Canadian waters and an assessment of the competence of the crew within two months after the commencement of operations.

(e) upon the acceptance and approval of the first report of the safety auditors on the operational safety of the rig, the regulatory authority issue an approval subject to the receipt and approval of the safety audit report on the competence and qualifications of the crew and compliance with any conditions that may have been attached to the conditional approval to drill. *(p. 49-53)*

(f) other audits be conducted, the depth and timing of which would be dictated by the outcome of the initial audit, the occurrence of significant events or the proposed transfer of the unit to a location of greater environmental hazards.

Classification societies and regulatory authorities apply empirical rules to assess the stability of a drilling rig. Mathematical and analytical methods may be used though they are not universally accepted. Research to develop more accurate methods of assessing stability is needed as is also the practical testing of the results of that research to compare the predicted with the actual behaviour of the rig. It is recommended:

92. That there be carried out on selected operating drilling rigs full-scale real-time measurements of the environmental conditions and the response of the rigs to those conditions for comparison with predicted behaviour. *(p. 42)*

Recent surveys by a major oil company disclosed flaws that should have been discovered through rigorous inspections during construction. Questions consequently arise regarding the quantity and quality of inspections carried out during the construction process. It is recommended:

93. That a critical assessment be made of the quality control inspections and the testing required during the construction of drilling rigs. *(p. 40, 43)*

When ice is threatening or when some of the anchor cables part in a storm, a drilling rig may be required to release its moorings at short notice. Drilling rigs in Canadian waters are required to have quick-release mooring systems, but there are no required standards and there is evidence that not all systems are reliable. It is recommended:

94. That performance standards for emergency release of moored drilling rigs within a specified time be established and that the reliability of the release system be tested for each drilling location. *(p. 26)*

The jack-up is the type of drilling rig most susceptible to damage. Jack-ups are particularly vulnerable to damage during transit. While afloat and while being transported on barges, they have suffered structural damage. It is recommended:

> **95.** That the regulatory authority undertake a critical review of the structural, stability and inspection requirements for jack-up drilling rigs, particularly during and following transits. *(p. 47)*

Critical systems, that is those systems deemed to be of crucial importance for the safety of the rig, have not been clearly designated nor do they need to be the same for every drilling rig. It is recommended:

> **96.** That the regulatory authority, in consultation with industry, identify for each drilling rig offshore those systems which are critical for its safety and the safety of its crew. *(p. 49, 50, Appendix C, Item 3)*

While existing Canadian rules provide in general an acceptable level of intact stability, the rules governing damage stability do not adequately provide for damage to floodable compartments below the waterline, for the weatherproofing of downflooding openings and for the protection, from the action of waves, of vents and of other features which may become downflooding openings, if they are damaged. The existing requirement for waterline damage is that the inclination of the rig must not exceed 15 degrees after one compartment is flooded. Other jurisdictions have different requirements, but experience has indicated that the one-compartment test is adequate. Damage resulting in flooding may, however, occur to compartments below the waterline. These compartments should be included in the damage stability calculations and provision made for redundancy of operation of any critical system contained therein. The capsize of the *Ocean Ranger* is an object lesson in the need for weatherproofing of downflooding openings. It is recommended:

> **97.** That to prevent downflooding due to the dynamic effect of waves and the rig's motions, weather-tight closures be required on any downflooding opening within a fixed distance above the waterline after damage. *(p. 46-47)*
>
> **98.** That where the stability requirements are met by a buoyant deck structure there be appropriate protection for the loss of that buoyancy as a result of wave impact in the damaged condition. *(p. 46-47)*
>
> **99.** That in calculating damage stability, allowance be made for the flooding of any one compartment adjacent to the sea, provided the compartments which are normally full in a given operating condition need not be considered in the calculation. *(p. 46-47)*
>
> **100.** That critical systems contained in compartments adjacent to the sea be required to be operable in the damaged condition including the flooding of those compartments, or that provision be made for redundancy. *(p. 46-47)*

Damage stability requirements reflect the view that damage to a drilling rig by external impact will generally occur at or near the waterline on the outer periphery. These requirements do not address the possibility of damage to the inner periphery of the rig, even below the waterline, by relatively small pieces of ice which, undetected and driven by large waves, may enter this area and cause substantial damage. There is insufficient knowledge of ice and its behaviour in high sea states and research is needed. It is recommended:

> **101.** That the adequacy of structural and damage stability requirements for drilling rigs be reviewed upon completion of research into ice impact damage. *(p. 27, 47)*

2.(b) "Inquire into, report upon and make recommendations with respect to inspection, inspection procedures, licensing classification and certification pertaining to the conduct of marine drilling operations."

In Report One, Recommendations 13 to 21 inclusive relate to this Term of Reference. They have either been acted upon or are under active consideration by the appropriate government agency. In this final report recommendations are made for the establishment of principles, performance standards and criteria (Recommendation 81); for a comprehensive safety audit of the rig as an integrated operating unit to be carried out against these principles, performance standards and criteria leading to a certificate of approval (Recommendation 91); for the endorsation and monitoring of industry's guidelines drawn up for the benefit of its members (Recommendation 84); and for the collection and dissemination of information regarding significant events (Recommendation 89).

The mode of ensuring compliance with or of exacting adherence to rules and regulations depends upon the objectives of the regulator, the specific nature of the regulation and the responsibility and the accountability of the operator and service contractor. It will depend on whether the objective is to monitor or to police; to seek assurance of suitability for safety or to assess blame; to develop sensitive attitudes and shared responsibility for safety or to ensure strict adherence to the law. Surely, the objective of the regulator and the regulatory system is to monitor, to assure safety, to develop a shared responsibility for safety and to impose penalties in the event of failure. The mode of ensuring compliance depends upon whether the regulations are specific and detailed or general and based upon standards acceptable to the regulator. Where they are specific and detailed, the role of the inspector, which is virtually completing a check list, requires limited special knowledge or experience. Where recognized performance standards are called for and particularly where they are unspecified but, as at present in Canada, must be acceptable to the Chief Conservation Officer, a much higher level of judgment and of experience is required. It is recommended:

> **102.** That within the single regulatory agency there be developed a capable Inspection Service to assure compliance with regulatory requirements of performance and that inspectors, where necessary, be transferred to it from line departments or other government agencies. *(p. 142)*

In a country with a nascent offshore oil industry there is a distinct shortage of persons qualified for the inspectorate envisaged in the previous recommendation. Consequently, it is not uncommon to engage external agencies such as classification societies; to employ, under contract, knowledgeable and experienced persons to certify compliance; or to attempt to recruit suitably qualified persons to ensure compliance with the regulatory requirements. Whatever the mode adopted, it is recommended:

> **103.** That where external agencies or contracted experts are engaged to ensure compliance with regulatory requirements, they do so on condition that they assume full responsibility for the accuracy of their reports.

The importance of establishing a very clear understanding of the responsibility and accountability of each of the parties involved in offshore petroleum activity under Canadian jurisdiction cannot be overemphasized. The increasing complexity of the industry has led to an organizational arrangement that fosters a dilution and diffusion of responsibility and accountability. There should be no confusion regarding the responsibility and the accountability of the drilling contractor and of the operator. The drilling contractor should unequivocally be responsible for the integrity of his rig and accountable for its safe operation. The operator should legally be accountable for all aspects of the operations under his permit. It is he who hires the MODU and from that fact he cannot escape responsibility for its quality and its performance. It is recommended:

104. That
(a) every effort be made to enforce the responsibility and accountability of the drilling contractor for the physical integrity of his rig, the operability of its critical systems, the quality of its management and the competence of its crew. *(p. 53)*
(b) the operator be held responsible and accountable for the integrity and safety of services provided to him under contract in the execution of his drilling program. *(p. 53)*

In the final analysis government agencies enforce compliance through penalties ranging from minor fines to cancellation of permits. In Canada where extension of domestic law to the continental shelf has not yet taken place, the *Oil and Gas Production and Conservation Act* specifies few offences, provides a limited range of penalties and gives wide discretionary powers to the Chief Conservation Officer. The penalties range from the discretionary to the draconian and are rarely imposed. It is recommended:

105. That a range of penalties be provided for failure to comply with regulatory requirements and the severity of penalties reflect the significance of the non-compliance. *(p. 143)*

The *Oil and Gas Production and Conservation Act* and the regulations issued under its authority confer unusually wide discretionary powers on the Chief Conservation Officer who is the head of the regulatory agency, both in the application of regulations, and in determining penalties for non-compliance. He has the authority even to suspend or dispense with the application of existing regulations. This situation results from the practice of using stipulations rather than regulations in the permit negotiation as the means of exercising mandatory controls. This system contains two inherent defects: it confers undue discretionary power on one statutory officer who is not even an elected minister and, through reliance on the provisions of the permit, it provides no graduated scheme of penalties. The need for a graduated scheme of penalties is covered in Recommendation 105, but for greater certainty and to avoid any suggestion of discriminatory treatment, it is recommended:

106. That
(a) the powers of the head of the regulatory agency be circumscribed and greater reliance placed upon published regulations and guidance notes as recommended in Recommendation 81. *(p. 137, 143)*
(b) provision be made in the legislation for an appeal to the minister by any person affected by a discretionary decision of the head of the regulatory agency.

EVACUATION SYSTEMS

2.(c) "Inquire into, report upon and make recommendations with respect to all aspects of safety of life at sea."

The lifesaving equipment for evacuating a drilling rig into the sea includes enclosed fibreglass lifeboats, inflatable life rafts and abandonment suits; of these, lifeboats are the primary means. To conclude that they are inadequate as a means of evacuation from a drilling rig in a severe storm is to state the obvious. In Report One it was recommended that utmost priority be given by Canadian authorities to the development of an improved evacuation system which would provide adequate and safe means of escape in foreseeable emergency and storm conditions.

Industry, through the Offshore Operators Division of the Canadian Petroleum Association, has indicated its interest in the development of a safe evacuation system. Government is arranging a survey of existing and newly-conceived evacuation systems and has expressed the intention of encouraging research into new systems and their testing. The Canadian Coast Guard has been appointed to co-ordinate the

research and, eventually, field test the systems. What is required is concerted action and without delay. The solution may not necessarily be a redesigned lifeboat; it may be a radically new concept. Performance standards should be established for evacuation systems and incentives devised for their development and installation. In the meantime, improvements should be made in the existing system. It is recommended:

107. That
(a) government and industry without delay establish performance standards and initiate a joint major engineering development project to produce a safe primary evacuation system for offshore drilling rigs. *(p. 104-105)*
(b) during the intervening period, it be a condition of the right to drill that existing primary evacuation systems be improved or replaced so as to improve materially their capability to evacuate the crew. *(p. 97-101)*

Life rafts, although not a desirable means of evacuation, may, under a given set of circumstances, be the only one available. In Report One it was recommended that life rafts on drilling units be davit launched. There are doubts about their stability and endurance in storm conditions and it is evident that they are not designed to be entered readily from the sea by persons wearing abandonment suits. It is therefore recommended:

108. That the standards for davit-launched life rafts be reviewed in order to determine their adequacy with particular respect to stability, method of construction and joining, and means of entry into them from the sea. *(p. 102-103)*

A joint government/industry committee has been organized under the direction of the Canadian Standards Association to develop standards for abandonment suits. In support of this worthy initiative, it is recommended:

109. That there be included, *inter alia*, in the standards for all types of abandonment suits, requirements for a greater number of sizes, improved neck seals, the use of radar-reflecting materials, strobe lights and personal locator beacons, the protection of the user's face from breaking waves, grips or other means to facilitate recovery, some form of head protection and the flotation of the wearer in an upright position. *(p. 103)*

There are no standard procedures or testing methods available to inspectors for ensuring that life jackets or abandonment suits continue to comply with performance standards such as buoyancy or thermal characteristics. It is recommended:

110. That the regulatory authority develop effective inspection and testing procedures for personal safety equipment.

RESCUE

Canadian regulations require that there be a standby vessel for each drilling rig operating on the continental shelf. Guidelines now state that it should keep station no more than one nautical mile from its drilling unit or at a distance such that the time for return to the drilling unit does not exceed 20 minutes. If helicopters, because of either weather or distance, cannot assist in evacuation, the standby vessel by reason of its proximity is the first source of rescue, but it has not been designed for a rescue role. Canadian regulations require a "suitable" standby vessel but suitability has not been defined. In Report One it was recommended that there be an immediate assessment of the capability and suitability of standby vessels used offshore eastern Canada. By late 1984 all but 7 of the 56 standby vessels were deemed to be suitable and a

Letter of Compliance was issued by the Coast Guard. In April 1985, information was received that COGLA and the Coast Guard, in consultation with industry, are developing criteria of suitability and that the Coast Guard would assess the standby vessels against these criteria. What criteria had been used in late 1984 is not known. While purpose-built rescue vessels may not be justified during the exploration phase, consideration should be given to what the production phase may warrant. It is recommended:

111. That the regulatory authority publish performance standards which determine the characteristics, equipment and supplies required for a vessel to qualify as a suitable standby vessel. *(p. 112-113)*

The Letter of Compliance issued by the Canadian Coast Guard for standby vessels, includes the provision of a "suitable launch/recovery system" for fast rescue craft (FRC) but there are no standards for that equipment. Masters of standby vessels have complained about the dangers of launching and recovering FRCs. If safely launched, they are the best available means for recovering persons from the sea, but their use may be restricted by an inadequate, improperly located launching system, and by "dead time" in the water until the motors are started. It is recommended:

112. That
(a) the regulatory authority develop performance standards which determine the characteristics of a suitable launching/recovery system for fast rescue craft. *(p. 112-113)*
(b) fast rescue craft be required to have engines which can be started and warmed up out of the water.

Effective rescue operations by standby vessels require a high degree of skill on the part of the entire crew who need to be of sufficient number for the varied duties to be performed. To this end, training in the use of FRC and other rescue equipment is needed for all members of the crew, both through courses and through regular exercises at sea. It is therefore recommended:

113. That
(a) the crew of a standby vessel be thoroughly trained as a rescue team, both through courses and through documented, frequent and regular exercises at sea and that each member of the crew receive, in addition, specialized training for assigned emergency duties.
(b) the number of crew members be sufficient to perform the varied duties required for rescue and treatment of survivors in the event of a disaster. *(p. 87, 112-113)*

Since 1982 commercial helicopters serving the drilling rigs have been upgraded. They have been equipped for hoists, Billy Pugh baskets and emergency multiple person rescue apparatus (EMPRA) and the crews trained in their use. They can also drop SEA kits. Hoists can be installed within 20 minutes. The rescue baskets are used to recover from the ocean persons who can help themselves. There are, however, no rescue technicians to aid the helpless. In the event of a major disaster these helicopters would be expected to perform a secondary search and rescue (SAR) role to supplement the rescue efforts of the helicopters specified in Recommendation 120. It is therefore recommended:

114. That helicopters under contract to the industry be equipped and available for rescue services in a secondary role; the crews be specially trained for that purpose and hoist operators and rescue technicians be readily available. *(p. 114)*

Industry has exceeded regulatory requirements in the area of emergency response in the creation of a series of multilateral agreements between the operating

oil companies to provide for integration of contingency planning, for common procedures for action, and for the elimination of road blocks to joint action. It is unfortunate that there has not been closer collaboration with government in the development of common policies. Steps have now been taken by industry and government to test the effectiveness of the system and to train, through exercises, key personnel in their essential roles under emergency conditions. It is recommended:

115. That
(a) government work closely with the industry in the development of an effective emergency response. *(p. 114)*
(b) realistic exercises be regularly held to test the effectiveness of the proposed response system and to train key personnel both at the drilling sites and on shore in the roles that would be thrust upon them in the event of a disaster. *(p. 114)*
(c) planning by government SAR personnel and the industry for search and rescue requirements for the production phase of oil and gas offshore begin forthwith.

The final responsibility for rescue is that of the state. That responsibility is exercised in Canada by the federal government. To examine critically the effectiveness of the search and rescue program in any part of the country requires an examination of the whole for it is only in the context of the whole, its guiding principles and mode of operations, that the quality and adequacy of the service in the part can be judged. The prime objective of federal SAR is to aid persons involved in air and marine incidents within the area of Canadian responsibility. It was in relation to that objective that facilities and resources have been acquired and deployed. No conscious deliberate attempt was made to extend SAR capability to the offshore where drilling now takes place. Supplementary resources for this purpose will be required. With few exceptions, neither the vessels nor the aircraft designated for primary SAR roles were designed for that specific purpose; rather, they were intended to serve the operational needs of the Department of National Defence and the Canadian Coast Guard. Levels of service have not been established nor criteria determined as a basis for evaluating the quality of service rendered. The result is that what has been delivered has been a set of discrete search and rescue activities provided by two separate departments rather than an integrated program developed to provide an adequate and timely response in the event of an emergency.

Much has been accomplished in the past decade but the stubborn fact remains that there is no single functioning agency with the mandate to knit together the several components into a comprehensive national SAR program. To that end, what is required is a distinct integrated structure under a lead minister who is not otherwise directly involved in providing search and rescue services from his departmental resources, and with managers who have no conflict of interest between departmental obligations and their SAR responsibilities. What is required is a co-ordinated program with a discrete budget that is a distinct element of the appropriate financial envelope. SAR requirements would then be assessed within the context of search and rescue policies; SAR vessels, helicopters, equipment and facilities would be assessed primarily in terms of their suitability for search and rescue functions and not be acquired for other purposes and then adapted to SAR functions. It is therefore recommended:

116. That
(a) a national SAR program be established with a distinct integrated structure: a co-ordinated program with a discrete budget as a distinct element of the appropriate financial envelope, under a lead minister who is not otherwise directly involved in providing search and rescue services and with managers who also have no inherent conflict of interest between their departmental operational obligations and their SAR responsibilities. *(p. 122)*
(b) search and rescue requirements be assessed within the context of search and rescue policies and SAR vessels and helicopters be assessed primarily in terms of their suitability for SAR functions.
(c) levels of search and rescue service be established.

It cannot be denied that accurate and continuing analysis of SAR incidents is essential for comprehensive planning, for formulating policy and deploying resources, for properly assessing and determining operational requirements and for guidance. An appropriate weighting system should be devised for the concentration of SAR-related incidents and for the concentration of marine activities and clients in order to assess the hazard to life associated with each incident. Adequate statistical data have not been assembled, correlated and analysed nor have sophisticated resources been made available for that purpose. It is recommended:

117. That a management information system be developed as a basis for the formulation of SAR policies, the assessment of SAR needs and the rational deployment of SAR resources. *(p. 119-120)*

The direction and co-ordination of search and rescue operations in the event of a major disaster require first-class facilities and sophisticated equipment as provided at Stavanger, Norway. These functions are performed within each region by the Rescue Co-ordination Centre. It is recommended:

118. That the Rescue Co-ordination Centre on the East Coast of Canada be fully equipped to the extent that modern technology permits.

The Canadian Coast Guard's primary SAR vessels have the same drawbacks as the standby vessels under contract to industry but they are not as fully equipped nor do their crews have either Basic Offshore Training (BOT) or Basic Offshore Survival Training (BOST), nor special training in rescue techniques. It is recommended:

119. That the suitability of the Coast Guard's primary SAR vessels be critically reviewed and also the training of their crews in rescue techniques. *(p. 118)*

As stated above, serious consideration has not been given to developing a search and rescue capability for the far offshore. Government search and rescue helicopters completed their capability update program (SARCUP) in June of 1984. Proponents say the Labrador/Voyageurs have thereby been made as good as new. They are, however, still 20-year old machines and lack much of the technological development achieved during that period. They have a relatively short endurance and lack auto-hover capability and other equipment needed for marine rescue operations. The auto-hover capacity would allow them to maintain a constant height above a moving surface, a capability which all helicopters involved in sea rescue operations ought to have. The Labrador/Voyageurs are therefore deemed to be unsuited for rescue operations offshore. Other more modern and longer-range helicopters that can be equipped with anti-icing equipment, auto-hover, direction-finding and homing equipment are available as are maintenance services. In the event of a major disaster offshore the helicopters under contract to the industry should be equipped to partici-

pate in rescue operations as stated in Recommendation 114. All helicopters involved in rescue operations should have auto-hover capability.

A federal SAR capability for the far offshore is also needed. For the Grand Banks, at least one long-range helicopter equipped to federal SAR standards should be provided by acquisition or by charter by the government for SAR purposes during the exploration phase; at least one for the Scotian Shelf and a third for the Labrador Sea while drilling is taking place. In the United Kingdom, a commercial helicopter is chartered by government for search and rescue purposes for the Shetland region. It is recommended:

120. That
(a) as a matter of priority all helicopters which may be required to conduct rescue operations offshore be equipped to have auto-hover capability. *(p. 119, 124)*
(b) for the Scotian Shelf, the government make available by acquisition or by charter at least one long-range helicopter, fully equipped to the extent that technology permits and manned to federal SAR standards to be dedicated full-time to a primary SAR role. *(p. 124)*
(c) for the Grand Banks, the government make available by acquisition or by charter at least one long-range helicopter, fully equipped to the extent that technology permits and manned to federal SAR standards to be dedicated full-time to a primary SAR role, and another helicopter similarily equipped, manned and dedicated for the Labrador Sea while drilling takes place there. *(p. 124)*

The success or failure of response to an emergency will be primarily a function of the time taken to respond. In the United Kingdom and Norway the standby times are 15 minutes during daylight and 45 to 60 minutes otherwise. Canadian standby is 30 minutes during normal working hours and 2 hours otherwise. It is recommended:

121. That the standby times of primary SAR helicopters be 15 minutes during daylight hours and 45 minutes at other times. *(p. 124)*

2.(d) "Inquire into, report upon and make recommendations with respect to all aspects of occupational health and safety."

There is a noticeable lack, worldwide, of useful data on which to base any meaningful assessment of offshore health needs and services. It is recommended:

122. That the regulatory authority take steps to establish a comprehensive data base that will provide timely, accurate and meaningful compilation and analysis of offshore accidents and illnesses. *(p. 83-84)*

While the operator is responsible for health care of all offshore workers who are part of the drilling program, this responsibility has often been delegated to the service contractors. Different standards of service and methods of health care delivery have been used. In some cases, the screening provided by the pre-employment medical has been inadequate or inappropriate. It is recommended:

123. That pre-employment medical examinations be required and the regulatory authority, in consultation with industry and its medical representatives, establish minimum standards for the content and scope of such medical examinations. *(p. 84, 85)*

The operator is responsible for planning and providing all health services for the drilling rig and for the qualifications of the medic who delivers these services. While the rig medic may be an employee of the drilling contractor, his professional activities should be under the direction of the operator's medical director. The rig medic position at present can be filled by an emergency technician, an ex-military paramedic (TQ6B), or a registered nurse.

The qualifications and experience of an emergency technician are considered unsuitable for the rig medic position. While the military medic qualification provides an appropriate background, there is a very limited pool of TQ6Bs available. Registered nurses with experience and appropriate specialist training are generally available and are well qualified to act as rig medics. Further, a well-developed system of professional accreditation for nurses is in place. It is recommended:

> **124.** That the minimum qualifications for a rig medic be a registered nurse designation, supplemented by experience in intensive care or emergency nursing. Under certain circumstances, an equivalent combination of training and experience may be accepted. *(p. 87)*

It has been indicated that the levels of medical and first-aid inventory are under review and that operators should ensure that inventories are maintained to their satisfaction and at levels appropriate for medical and first-aid treatment. Standards are required for medical equipment, supplies and drugs. It is recommended:

> **125.** That the regulatory authority, in consultation with industry and its medical representatives, establish standards for the minimum levels and types of drugs, medical supplies and equipment to be available on board each drilling rig and standby vessel. *(p. 86, 113)*

A diver in trouble during a dive will have immediate assistance available only from another diver. It is important, therefore, that all divers receive considerable training in emergency first aid. A diving contractor employs a number of life-support technicians to maintain above-water equipment and to monitor dives. The rig medic is expected to be familiar with hyperbaric medicine, but, normally, it is the diver medical attendant who enters any pressurized chamber to assist an injured diver. Draft regulations do not provide details on the medical training and qualification requirements of support personnel during diving operations. There is an adequate shore-based hyperbaric medical facility in Nova Scotia but not in Newfoundland. It is recommended:

> **126.** That
> (a) *The Canada Oil and Gas Diving Regulations* (Draft) be promulgated without delay, and that they include training standards for diving support personnel, including positions providing life-support services to the divers. *(p. 88)*
> (b) an adequate hyperbaric medical facility be established in Newfoundland. *(p. 88)*

The Canadian regime for the provision of health care services to offshore drilling operations is more complex than that of Norway or the United Kingdom because of the division of powers under the Canadian Constitution and the number of agencies involved. Responsibility for health within provincial boundaries rests constitutionally with the provincial legislature. A mechanism is needed to provide effective co-operation between both levels of government and with industry. It is therefore recommended:

> **127.** That a joint federal-provincial committee on health be established consisting of medical representatives from both levels of government and from industry to consider and advise on all aspects of health care in offshore drilling operations. *(p. 87)*

2.(e) "Inquire into, report upon and make recommendations with respect to the certification, training and safety of the officers and the crew and their respective responsibilities including those of the master and toolpusher."

Crucial to safe operations offshore and to the reliable capacity of a crew to meet the unexpected are the competence of the crew and the confidence that they have in their training, in themselves and in their colleagues. Training standards need to be established and programs developed and approved to provide the required level of competence. A Joint Government-Industry Offshore Training Committee has been established to examine these issues. What is needed is an Offshore Petroleum Training Standards Board, established on a statutory basis with a relatively small membership drawn from persons with a first-hand understanding of offshore operations and from persons with special competence in training. The insight of workers having substantial experience ought also to be represented. The proposed board should be authorized to determine requirements for training offshore, to approve course requirements and training organizations and to determine equivalencies. Underlying all questions of training for safety in the offshore is the issue of reconciling the mixture of marine and industrial characteristics of operations. From this issue stems the questions of certification, of whose responsibility it is to determine standards, and of what positions should be certified.

The Offshore Operators Division of the Canadian Petroleum Association, in collaboration with the Canadian Association of Oilwell Drilling Contractors, has recently recommended minimum qualifications and training standards for all the basic tasks of the rotational crew of the drilling contractor. In early 1985, an interdepartmental working group of representatives from the Canadian Coast Guard, COGLA, and Employment and Immigration Canada issued a draft report proposing, *inter alia*, training requirements for MODU endorsements to marine certificates and also marine training requirements for senior industrial personnel. The proposed Board should co-ordinate these two proposals and be given the responsibility of approving all industrial training endorsements for marine positions on MODUs.

It is important to distinguish between certified positions and positions for which the minimum training requires certification of particular skills. A rig electrician for example, is required to have an *Industrial Electrician's Certificate*. For some positions industry specifies minimum qualifications for which there may not be associated certificates. A toolpusher is required to have training in well control, though there is no certificate for the position of toolpusher, there is an industrial certificate issued for well control training. Certificates give evidence of the possession of minimum requirements. It is the responsibility of the employer to determine whether the holder of the certificate is suited to a particular job. It is recommended:

128. That

(a) an Offshore Petroleum Training Standards Board be established by statute composed of a few members among whom should be persons with first-hand knowledge of offshore operations, with special competence in training, and with the experience and insight of workers.

(b) the Board be vested with the authority to establish training and qualifications standards, certification and recertification requirements, verification and audit measures, and the requirement for, and approval of, training institutions and facilities.

(c) the Board establish and maintain a program of certification of training in those skills which are judged to be critical to safety, including the delineation of certificated skills required, if any, for each position, and the scope and the content of certificated specialist training.

(d) the Board be assigned the responsibility to establish the requirements for and to approve all MODU endorsements of positions which are the subject of marine certification by the Canadian Coast Guard or its foreign equivalent. *(p. 75-79)*

There is general agreement that basic safety training is necessary for all full-time offshore workers. Industry would prefer this training to follow a period of employment on the rig because of the large turnover of employees and because of the greater benefit to be derived from the course after a period of experience. There is also some debate regarding the components of basic training and the degree to which emergency functions should be left to specialist teams. There is also a question of the basic training to be required for occasional workers. The question of the content of basic safety training is fundamental and should be addressed without delay by the regulatory authority and their decisions subject to subsequent review by the proposed Board. It is recommended:

129. That as an interim measure pending formation of the Offshore Petroleum Training Standards Board, the regulatory authority immediately establish uniform standards for basic safety and emergency training for regular and occasional offshore workers.

There are a number of emergency duties that are best carried out by trained specialist teams. These teams should include well control, ballast control, fire control, advanced first aid, lifeboat operations, helicopter landing, and man overboard. Special training should consist of initial training followed by regular and frequent drills by small cohesive groups. Familiarization with the specific drilling rig and its equipment is essential as are incentives to emphasize the importance of the teams and adequate time and resources for training. It is recommended:

130. That specialist emergency teams be established on each drilling rig and be highly trained. *(p. 76)*

Training, to be effective, must be realistic, of high quality and delivered by capable instructors with first-class equipment. Workers, as stated earlier, must not only be competent but also be confident in that competence, both their own and that of their fellow workers. It is therefore essential that training facilities of high quality be readily available. It is recommended:

131. That

(a) the regulatory authority ensure that programs and facilities of the highest order are available for basic safety training, for specialist training and for designated industrial and marine positions.

(b) the provision of this high quality training recognize the need: (1) for ease of access to basic safety training; (2) for specialist training, where required, to be concentrated in a single centre with research resources available; and (3) to avoid duplication of training resources. *(p. 78)*

The issue of who should be in command of the rig is obscured by the marine and military connotation of the word "command" and the differing practices adopted in other jurisdictions. In an industrial setting, it is normal to ask who is in charge. The person in overall charge of any enterprise normally delegates authority and responsibility for a specific aspect of the operation to the person who has the appropriate qualifications and experience. In like manner, when problems on an offshore drilling rig develop in controlling the well, the operator's senior representative takes charge of remedial action. When it is a marine-related problem, the master acts. When problems develop downhole in the drilling operation or because of malfunction of equipment, the toolpusher has charge of corrective action.

Whether the master or the toolpusher is the person appointed by the drilling contractor to be in overall charge of a semisubmersible varies with the country of registry, the corporate policies of the drilling contractor and the regulatory requirements of the Flag and the Coastal State. On those rigs organized on the Norwegian model, the master is in overall charge at all times; on those on the United States

model, the toolpusher is in charge while the rig is in the drilling mode. In Canada an interdepartmental working group composed of COGLA, Coast Guard, and Employment and Immigration Canada has recommended that there be at all times an offshore installation manager and has laid out career paths for both mariners and drillers to hold that appointment.

Emergencies may occur to a semisubmersible because of collision, loss of stability, storms, or industrial hazards such as loss of well control. What is essential is that, when emergencies occur, all members of the crew should know in advance from whom they are to take direction. When lives are at stake, there should be no question regarding who is in charge. One person should be clearly in charge of the rig at all times. The solution to be desired, and the one to be implemented as soon as it is feasible to do so, is to place in charge of the semisubmersible one who has knowledge and experience in both the drilling and marine aspects of the operation and who has the necessary leadership qualities. In support of the recommendation of the interdepartmental working group, it is therefore recommended:

132. That
(a) the offshore installation manager be the person in charge of the semisubmersible at all times and he be knowledgeable and experienced in both drilling and marine matters. *(p. 63)*
(b) within a fixed period of time, the person in command of a semisubmersible be so qualified.
(c) consideration be given to a lesser requirement for the person in overall charge of a jack-up when it is fixed on location.
(d) the master of a drill ship have a MODU endorsement of his master's ticket.

2(i) "Inquire into, report upon and make recommendations with respect to any related matter."

Offshore workers appear to be reluctant to voice their concerns. To the extent that concerns are related to safety there is need for some means not only of permitting worker participation in safety management but also of encouraging the practice. Provision should be made for the election of a representative by the workers, access by that representative to senior rig personnel and to regulatory inspectors and assurance of protection for his position. It is recommended:

133. That each operator develop and submit for approval a "safety representative" process which ensures all workers an effective means of expressing safety concerns and of knowing what actions are taken to relieve them and that this process be monitored by the regulatory authority. *(p. 67)*

Any investigation of an accident in a regulated industry requires the scrutiny not only of the industrial aspect, but also of those aspects which are the function of the regulator and its inspectors. If an investigation is carried out by the body responsible for establishing and enforcing the regulatory regime, the obvious potential for conflict of interest arises. In a disaster, such as the *Ocean Ranger*, society's need of inquiry is met by the appointment of a Royal Commission. It seems however, that there should exist a competent standing capability to launch immediate investigations into major offshore accidents, such as the Aviation Safety Board does in the event of an air disaster. In Recommendation 83 of the *Study on Marine Casualty Investigations in Canada* (Deschênes Report), it was recommended that the investigating authority be a government agency that is independent of other aspects of the regulatory function. It is therefore recommended:

134. That an independent agency be established with statutory authority to investigate defined categories of accidents arising during offshore drilling operations, relating to either the marine or the industrial facets of the activity.

The Conference on Safety Offshore Eastern Canada, organized by the Royal Commission, brought together from the international community knowledgeable persons concerned with offshore drilling operations. Experts from the key disciplines debated the basic issues being addressed by the Royal Commission and illuminated possible new directions and opportunities for improvement. Those who participated agreed that an unusually valuable opportunity had been provided for consultation among a group which was representative of the principal sectors involved. Recognizing the usefulness of informed debate about policy and process on a continuing basis, it is recommended:

> **135.** That the Government of Canada encourage and support the convening in Canada of a biennial conference on offshore safety.

The maintenance of a productive ecosystem is essential to sustain all forms of life on this planet. As with most human activities, the exploration for and exploitation of offshore hydrocarbons represents some degree of threat to elements of that ecosystem, and hence in the broadest sense, to human safety. Man now recognizes the need to understand and control the ecological consequences of his activities and, with exploration increasing and exploitation approaching, time and attention must be paid to defining and ameliorating the environmental effects of these activities. It is therefore recommended:

> **136.** That government and industry continue to fund and increase their support for studies on the effects of pollutants on the marine environment and for the development of means to reduce the likelihood of and consequences from such pollution. *(p. 176)*

EPILOGUE ENVIRONMENTAL SAFETY

EPILOGUE ENVIRONMENTAL SAFETY

There has been much speculation and public concern about the effects of offshore petroleum exploration activity on the plants and animals that comprise the biological component of the marine environment. Offshore exploration is normally conducted in areas of relatively shallow water, areas which are often productive fishing grounds. As exploration, and, ultimately, production increase, so too will the risk of pollution and public concern about its consequences.

Under normal operations an exploration drilling activity is relatively clean, compared with other maritime activities. A minimum of pollutant materials are released into the environment and these are generally of negligible consequence. Modern drilling units are equipped with sewage treatment facilities, and kitchen wastes and other garbage are usually transported to shore for proper disposal. The cuttings from the actual drilling, soaked in the drilling mud that is used in most offshore drilling programs, are disposed of over the side. Only in exceptional circumstances have drilling muds produced any measurable effect on the environment. In most other regards the exploration drilling activity is no more disruptive of the natural environment than is fishing or merchant shipping activities. The major environmental threat is posed by the hydrocarbons themselves which are the object of this drilling activity.

Should there be a catastrophic failure of the devices and procedures used to control the pressure in the well, a blowout will occur and reservoir fluids will make their way to the surface. These could be water, gas, oil or condensates. There have been some notable blowouts, such as occurred on the Ekofisk field in the North Sea in 1973 and at the Ixtoc well in the Gulf of Mexico in 1979. Blowouts are unusual events, rare in the offshore. The threat posed by them is real, however, and to date there have been two such losses of well control on the Scotian Shelf. Fortunately, as yet no environmental damage has resulted from these incidents. A blowout carries with it the threat of an uncontrolled release of oil for a protracted period of time until well control can once again be obtained; the Ixtoc blowout, for example, lasted for nine months.

It has been said that "the advance of technology carries within it the threat of destruction" but it is equally true that advancing technology will lead either to more effective means of minimizing the effects of pollution or to more efficient and advanced means of preventing it. As both industry and government improve their monitoring systems, and as new technologies in well control are developed, risks to the environment become progressively minimized. In a more global context, as the exploitation of oil takes place closer to its point of consumption, the reduced tanker traffic may, in fact, result in less rather than greater pollution from oil spills. Even with present technology, the occurrence of blowouts can be minimized and their

FIGURE 1. A semisubmersible drilling rig engaged in well testing on the Grand Banks. Oil, gas and condensate which flow from the well during testing are disposed of by burning.

effects controlled to some degree through various methods. Some of the equipment used in response to an oil spill such as booms to contain the oil, skimmers and absorbants to recover it, and dispersants to break up the slick have been used with varying degrees of success in different locations and under various circumstances. Nonetheless, the ability to contain and recover spilled oil in the open ocean under any but relatively calm conditions is minimal. Research and development have led to improved devices and products based on earlier experiences, and the toxicity that was characteristic of the previously used dispersants has been vastly reduced in the new products.

In many locations off eastern Canada, an oil spill could very well be driven offshore into deeper waters by the prevailing wind and currents. If the oil were to come ashore, however, its effects would vary with the nature of the coastline. In high-energy areas where the coastline is exposed to wave action, oil is weathered relatively quickly and its effects are transient. On low-energy beaches and marshes, however, oil is persistent and its effects are prolonged. Oil will also foul fishing gear, fishing vessels and wharfs. The public perception of the disastrous effects of oil spills has been almost exclusively associated with the shoreline damage created by the release of a huge volume of oil over a relatively short period of time and close to shore, as occurs with the loss of an oil tanker. This review, however, addresses the environmental risks and biological effects of a different type of oil spill, one that occurs at sea and involves a prolonged release of oil, albeit at a much lower rate than can occur from a supertanker spill.

The relationship between different forms of marine life can be described as a food web made up of many connectors, or, it may be likened to a pyramid, with a broad base representing many individuals supporting fewer individuals above it, the numbers decreasing at each level until finally the apex is reached, which may represent, for example, seals. All levels of the web or the pyramid are supported by a larger base beneath, forming a food and energy source for the levels above. Break the web, or destroy the pyramid and the entire community is disturbed, distorted or

destroyed. At the base of the pyramid are the bacteria, then the microscopic, planktonic plants or phytoplankton (the producers of organic material in the sea), above which are the consumers which are basically incapable of producing organic matter and must gain it at the expense of the producers (the phytoplankton), for example the planktonic animals (zooplankton) upon which the fish and birds feed.

The consequences of an oil spill on the phytoplankton off eastern Canada, particularly on those forms suspended or drifting in the upper water column, will likely be undetectable and negligible. The worst effects will be restricted to definite areas of high level contamination. In the open sea, the effects on fish stocks of the suppressed production of primary organic material resulting from the mortality of phytoplankton will be slight, if indeed detectable. Not all primary organic producers are planktonic, however, nor are they adrift in the water column. Some are found on the seabed in relatively shallow water as well as on submerged structures. The effects of oil spills in these cases will be local.

At the next level in the food web are the microscopic animal drifters or zooplankton. The same generalizations concerning the effects of oil spills on phytoplankton will apply to them as well. Fish eggs, larvae and juveniles are much more vulnerable to oil than are the adult fish. Investigations have shown that they are less capable of detoxifying petroleum hydrocarbons, and are insufficiently mobile to escape and thereby avoid contamination. Many eggs and larvae are buoyant and, as a consequence of their immobility, they can be exposed to oil at the surface long enough for high mortalities to occur. This effect is obscured because at these stages of the life cycle fish have a natural mortality rate in the order of up to 10 percent daily. As in all other cases, the impact of oil on these forms of fish life is influenced by a multitude of factors, including the configuration of the water basin itself, its depth and the pattern of the water currents. On mature fish the effect will probably be insignificant. Fish have the ability to swim and move about, and they can therefore escape areas which come under the influence of pollutants. Further, there is evidence that adult fish have the ability to detoxify hydrocarbons. Nonetheless, biochemical evidence does exist indicating that there are effects from exposure of some adult fish species to oil, which are not measurable in terms of mortality. Pollutant-induced pathological changes in their gills, liver or eye-lens tissue have been reported and these could, in time, take their toll.

Information on the effects of oil on marine mammals is extremely limited, as there have been very few definitive experimental studies conducted to date. Their lifestyle, their habits and their rearing of young cause both adults and young to be potentially liable to come into contact with oil. The colonial habits of most seals and of some other marine mammals expose whole populations rather than just individuals to the effects of discharges of oil. It has been learned through short-term experimentation that exposure to relatively high concentrations of oil causes a loss of thermal insulation and of waterproofing as well as causing irritation to the eyes and the exposed mucous membranes. The long-term effects of a seal being coated with relatively large concentrations of oil are not known. Biochemical information indicates that, unlike fish or marine invertebrates, marine mammals have efficient mechanisms to permit the mammals to metabolize the hydrocarbons and it is unlikely that the ingestion of small quantities of oil would seriously harm these animals. It is not known, however, whether marine mammals possess the ability to avoid areas of oil spills since field observations have indicated that they do not necessarily navigate away from areas of oil contamination.

The highest biological risk factor involves sea birds. The coast of eastern Canada supports several million breeding pairs of marine birds comprising the majority of the western Atlantic population of all marine bird species except Dovekies and Roseate Terns. Ornithologists have concluded that the Grand Banks are the single most important feeding area for marine birds in the North Atlantic. For this fact alone oil

FIGURE 2. The major sea bird colonies of eastern Canada.

spills offshore take on their greatest biological significance. It is also recognized that the sea bird colonies assume a great importance in the public consciousness since the effects of oil spills on bird populations are readily apparent, even to the most casual observer.

A summary of marine bird populations breeding in four areas of eastern Canada (Nova Scotia, Newfoundland and the Gulf of St. Lawrence; Labrador; Hudson Strait and Hudson Bay; and the High Arctic) is presented in Table 1. Reference to this table will indicate that the vast majority, about three million birds, are concentrated in eastern Newfoundland. The major sea bird colonies in eastern Canada are shown on the map in Figure 2.

Information on the distribution of birds foraging away from these colonies during the breeding season is only partially known. A high proportion of Atlantic Puffins and Common Murres from the colonies in eastern Newfoundland are believed to feed within a few kilometres of the shore during capelin spawning periods. On the other hand, pelagic species such as Leach's Storm Petrel and the Northern Fulmar range widely, and reportedly cover extensive portions of the continental shelf. Thick-billed Murres breeding in Lancaster Sound and in Hudson Strait are known to forage up to 120 kilometres from their colonies. In Labrador, Atlantic Puffins, Common Murres, and Razorbills forage up to 40 kilometres from their colonies on the Gannet Islands. From these observations, it is evident that these species venture to sea and may enter areas of oil spill.

In addition to the breeding birds, the numbers of avian species and individuals are augmented in the summer months by visitors from the southern hemisphere spending the austral winter in Canadian waters. The most important of these is the Greater Shearwater, of which several million visit the Grand Banks annually from July to September, extending as far north as Greenland. Smaller numbers of Sooty Shearwaters come north to Newfoundland, and substantial numbers of pre-breeding Northern Fulmars from the eastern North Atlantic populations also visit the Grand Banks and even further north.

In addition to all these, the marine birds from the high Arctic, from eastern Canada and from western Greenland are supplemented in winter by emigrants from the eastern Atlantic, with birds coming to Newfoundland and to the Labrador Sea from as far away as Spitzbergen and northwest Russia. Although it is difficult to determine their populations precisely, these winter visitors have been estimated to be more than 19 million birds in addition to the large numbers of Common Eiders and other ducks which stay throughout the winter.

The avian population placed in risk by oil pollution is therefore very large indeed. Relatively little is known about the actual migration corridors or the important staging areas of pelagic birds. What is known, however, is that a large proportion of them, whether native or visiting, would be potentially exposed to pollution if an oil spill should occur. Many would be young-of-the-year, compelled to spend much of their migration time on the water, and thus most susceptible to the pollution.

Sea birds have very few predators other than man. That man does prey upon sea birds is confirmed by the fact that between one-quarter and one-half million murres, mainly Thick-billed Murres are shot annually in Newfoundland and Labrador.

Sea birds die from a combination of causes when they come into contact with oil. Oil may mat their feathers to such an extent that they become incapable of movement. Soiled plumage loses its insulating properties and the bird must expend more energy than usual on thermal regulation. The oil can also be transferred to incubating eggs with a consequent reduction in hatching rates. At lower intensities of oil coverage, birds swallow oil while preening and suffer from a variety of toxic effects including increased metabolism and decreased digestive efficiency. It is not

TABLE 1
Summary of Marine Bird Populations (individuals x 1000)
Breeding in Four Areas of Eastern Canada

SPECIES	NOVA SCOTIA NEWFOUNDLAND GULF OF ST. LAWRENCE	LABRADOR	HUDSON STRAIT HUDSON BAY	HIGH ARCTIC
Northern Fulmar *(Fulmarus glacialis)*	(1)	(1)	—	720
Leach's Storm Petrel *(Oceanodroma leucorhoa)*	1600	(1)	—	—
Northern Gannet *(Sula bassana)*	51	—	—	—
Cormorants *(Phalacrocorax carbo, auritus)*	22	—	—	—
Common Eider *(Somateria mollissima)*	76	40	200	50
Large Gulls *(Larus argentatus, marinus)*	>50	>10	>5	>10
Black-legged Kittiwake *(Rissa tridactyla)*	219	(1)	10	180
Arctic Tern *(Sterna paradisaea)*	>1	>1	>10	>5
Razorbill *(Alca torda)*	8	38	(1)	—
Common Murre *(Uria aalge)*	1023	112	—	—
Thick-billed Murre *(Uria lomvia)*	5	19	1340	1280
Black Guillemot *(Cepphus grylle)*	>5	>5	>40	>20
Atlantic Puffin *(Fratercula arctica)*	511	153	(1)	(1)
TOTALS	3571	378	1605	2265

NOTE (1) Present, but fewer than 1000 individuals.

Source: *Environmental Risks from Offshore Exploration*
Fisheries and Oceans Canada, Newfoundland Region Environment Canada, Atlantic Region January 1984

possible to predict the exact effect of oil on any given species of birds. Some species have been shown to clean themselves without ill effects, while others have succumbed after only a very light soiling with oil.

The species that are most vulnerable to oiling are those which spend most of their time on the surface. Oil in heavy concentrations, as indicated earlier, would affect the birds' food supplies either by destruction or by contamination of lower levels in the food web. Eider Ducks are particularly vulnerable since they feed predominantly on bottom-dwelling animals which filter their food from the water and which may thereby concentrate toxic substances.

It has been estimated that a major oil spill at the Hibernia site can be expected to move across areas on the continental slope at the edge of the Grand Banks, which support large concentrations of marine birds throughout the year. Species particularly at risk would be, in winter, Common and Thick-billed Murres and Dovekies and, in summer, Northern Fulmars and Greater Shearwaters. A worst case scenario, one involving a slick of oil covering 1,000 square kilometres, could kill as many as one-fifth of Dovekies and Murres wintering off Newfoundland. Of equal significance is the fact that a spill of that dimension would probably be felt in all transient populations, and that at best they would take several years to recover.

A major spill in the Labrador Sea would have greatest effect on sea birds in September to October when large numbers of Thick-billed Murres, Northern Fulmars, Black-legged Kittiwakes, and Phalaropes pass through the area. At worst, a

FIGURE 3. Drilling in the Labrador Sea is possible only during the summer and early fall, when the area is relatively ice-free. The drilling season coincides with the arrival of vast numbers of migratory sea birds.

large proportion of the young and flightless as well as the adult Thick-billed Murres from colonies in Hudson Strait would be drastically affected.

The use of dispersants to combat oil spills would benefit sea birds in a polluted situation. Dispersants, however, enhance the release of toxic properties of the oil until it is incorporated into the water column and place other forms of marine life in greater danger than that posed by a spill alone. Where sea birds are not greatly at risk, the benefits of the use of dispersants would have to be weighed against possible adverse consequences for fish larvae and marine invertebrates.

Oil pollution in the offshore environment will have an effect upon all levels of life within the marine ecosystem from bacteria, plants and lower animals, fish and mammals to birds. The mode of life of some marine forms will cause greater exposure and result in greater susceptibility than for others. Commercial species of fish will be the least exposed and sea birds the most endangered. Greater threats to marine life and the marine environment are posed daily from the activities of ships passing through the areas in question, and particularly the discharge into the water of their oily bilges. The potential harm from bilge exceeds that from oil spills.

The potential for oil pollution, whether due to exploration, production or maritime activity, is likely to increase with an escalation in activity along the East Coast. The negative consequences of future oil pollution will depend on a number of factors including the chemical and physical properties of the oil, the volume spilled, the location of the spill, the prevailing weather conditions at the time of the spill, and the nature of the segment of the biota affected. It can be expected that oil pollution may have serious, though temporary, local consequences for most populations on the lower ends of the food chains, with a consequent reduction in primary productivity. Particularly vulnerable, and obviously so, are the millions of sea birds that characterize our immediate coastal areas which they must now share with offshore oil exploration and production.

Knowledge of individual organisms, species, and populations at all levels of productivity in the marine environment is needed. The study of the effects of pollutants on the living components of the marine environment is a proper and desirable investigation for biologists and ecologists to undertake. The risk of environmental disaster is a challenge for them to solve by providing the information needed to assess the results of offshore operations, and thus to calculate appropriate limits for those operations.

THE ROYAL COMMISSION APPENDIX A

APPENDIX A

THE ROYAL COMMISSION

ITEM A-1

ROYAL COMMISSION STAFF

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ITEM A-2

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ITEM A-3

Terms of Reference
Canada

The Order of the Governor-in-Council No. PC 1982-819 dated the 17th day of March A.D. 1982

Certified to be a true copy of a Minute of a Meeting of the Committee of the Privy Council, approved by His Excellency the Governor General on the 17 March, 1982.

WHEREAS the Committee of the Privy Council has had before it a report of the Prime Minister submitting that it is essential that an Inquiry be made into the matters hereinafter set forth in paragraphs 1 to 3 below.

Therefore the Committee of the Privy Council on the recommendation of the Prime Minister advise that the Honourable T. Alexander Hickman, Chief Justice of the Trial Division of the Supreme Court of Newfoundland, the Honourable Gordon A. Winter, Moses Morgan, Esq., Fintan J. Aylward, Queens Counsel, Bruce Pardy, Esq. and Jan Furst, Esq., all of the Province of Newfoundland, be hereby appointed Commissioners under Part I of the Inquiries Act to:

1. Inquire into and report upon the loss of all members of the crew of the semi-submersible self-propelled drill rig *Ocean Ranger*, and of the *Ocean Ranger*, on or about the 15th day of February, 1982 on the Continental Shelf off Newfoundland and Labrador, the reasons and causes therefor and, without restricting the generality of the foregoing, to inquire into, report upon and make recommendations in respect of the following matters:
   (a) the design, construction and stability of the *Ocean Ranger* and its suitability to conduct marine and drilling operations on the Continental Shelf off Newfoundland and Labrador;
   (b) inspection, inspection procedures, licensing, classification and certification pertaining to the conduct of marine drilling operations by the *Ocean Ranger* on the Continental Shelf off Newfoundland and Labrador;
   (c) all aspects of safety of life at sea, including the sufficiency of life saving equipment on board the *Ocean Ranger* and whether such life saving equipment was used or could have been used;
   (d) all aspects of occupational health and safety which related to the officers and crew of the *Ocean Ranger*;
   (e) the certification, training and safety of the officers and the crew and their respective responsibilities including those of the Master and the Toolpusher on board the *Ocean Ranger*;
   (f) the search and rescue response and any other emergency response thereto, both from within Newfoundland and elsewhere;
   (g) oil pollution prevention procedures and whether the drill hole was left in a safe condition prior to or at the time of the casualty;
   (h) any acts or omissions of the owner, the charterer, the operator or any contractor in respect thereto; and

Terms of Reference
Province of Newfoundland

The Lieutenant Governor-in-Council's Commission dated the 16th day of March A.D. 1982

ELIZABETH THE SECOND by the Grace of God of the United Kingdom, Canada and Her Other Realms and Territories QUEEN, Head of the Commonwealth, Defender of the Faith.

W. Anthony Paddon
Lieutenant-Governor

COMMISSION

TO: The Honourable T. Alexander Hickman,
Chief Justice of The Trial Division
of the Supreme Court of Newfoundland
(Chairman),
The Honourable Gordon A. Winter, O.C., LL.D.,
Moses O. Morgan, C.C.,
Fintan J. Aylward, Q.C.,
Jan Furst, Esq., and
Bruce Pardy, Esq.

WHEREAS it appears desirable and expedient that an enquiry be made into the loss of life resulting from the sinking of the *Ocean Ranger* on February 15th., 1982.

NOW KNOW YE that under and by virtue of The Public Enquiries Act Chapter 314 of The Revised Statutes of Newfoundland, 1970, We, by and with the advise of Our Executive Council of Our Province of Newfoundland, reposing great trust and confidence in your knowledge, integrity and ability, have constituted and appointed and do by these presents constitute and appoint you the said T. Alexander Hickman, Gordon A. Winter, Moses O. Morgan, Fintan J. Aylward, Jan Furst, and Bruce Pardy
to be Commissioners to hold an enquiry into the matters following, that is to say:

1. Enquire into and report upon the loss of all members of the crew of the semi-submersible self-propelled drill rig *Ocean Ranger*, and of the *Ocean Ranger*, on or about the 15th. day of February, 1982, on the Continental Shelf off Newfoundland and Labrador, the reasons and causes therefor and, without restricting the generality of the foregoing, to enquire into, report upon and make recommendations in respect of the following matters:
   (a) the design, construction and stability of the *Ocean Ranger* and its suitability to conduct marine and drilling operations on the Continental Shelf off Newfoundland and Labrador;
   (b) inspection, inspection procedures, licensing, classification and certification pertaining to the conduct of marine drilling operations by the *Ocean Ranger* on the Continental Shelf off Newfoundland and Labrador;
   (c) all aspects of safety of life at sea, including the sufficiency of life saving equipment on board the *Ocean Ranger* and whether such life saving equipment was used or could have been used;

(i) any other related matter.

2. Inquire into, report upon and make recommendations with respect to:

(a) both the marine and drilling aspects of practices and procedures in respect of offshore drilling operations on the Continental Shelf off Newfoundland and Labrador and without restricting the generality of the foregoing, the matters referred to in paragraphs 1.(a) to 1.(e) as they related to other drilling units conducting marine and drilling operations on the Continental Shelf off Newfoundland and Labrador; and

(b) to the extent necessary and relevant, such practices and procedures in other Eastern Canada offshore drilling operations.

The Committee further advise that:

(a) the establishment of this Commission and the appointment of the Commissioners hereunder is without prejudice to both the claim of the Government of Canada and the claim of the Government of Newfoundland to legislative jurisdiction and proprietary rights on or in respect of the Territorial Sea or the Continental Shelf off Newfoundland and Labrador; and

(b) notwithstanding the terms of reference set forth in this Order in Council, the Commissioners be directed not to consider, comment upon nor make recommendations in respect of the claims to jurisdiction and rights aforesaid.

The Committee further advise that:

(a) the Honourable T. Alexander Hickman be the Chairman of the Commission and that the Honourable Gordon A. Winter be Vice-Chairman of the Commission;

(b) the Chairman and the Vice-Chairman be authorized, after consultation with the other Commissions, to:

(i) adopt such practices and procedures for all purposes of the Inquiry as may from time to time be necessary for the proper conduct of the Inquiry and, after consultation with the other Commissioners, vary those practices and procedures from time to time;

(ii) engage the services of counsel to aid and assist the Commissions in the Inquiry at such rates of remuneration and reimbursement as may be approved by the Treasury Board;

(iii) rent such space for offices and hearing rooms in consultation with the Department of Public Works and according to the practices of the Department;

(iv) engage the services of such accountants, engineers, technical advisors or other experts, clerks, reporters and assistants as they may deem necessary or advisable, at such rates of remuneration and reimbursement as may be approved by the Treasury Board; and

(v) exercise all powers conferred upon them by subsection (2) to subsection (4) of section 11 of the Inquiries Act;

(d) all aspects of occupational health and safety which related to the officers and crew of the *Ocean Ranger*;

(e) the certification, training and safety of the officers and the crew and their respective responsibilities including those of the Master and the Toolpusher on board the *Ocean Ranger*;

(f) the search and rescue response and any other emergency response thereto, both from within Newfoundland and elsewhere;

(g) oil pollution prevention procedures and whether the drill hole was left in a safe condition prior to or at the time of the casualty;

(h) any acts or omissions of the owner, the charterer, the operator or any contractor in respect thereto; and

(i) any other related matter.

2. Enquire into, report upon and make recommendations with respect to:

(a) both the marine and drilling aspects of practices and procedures in respect of offshore drilling operations on the Continental Shelf off Newfoundland and Labrador and, without restricting the generality of the foregoing, the matters referred to in paragraphs 1.(a) to 1.(e) as they relate to other drilling units conducting marine and drilling operations on the Continental Shelf off Newfoundland and Labrador; and

(b) to the extent necessary and relevant, such practices and procedures in other Eastern Canada offshore drilling operations.

AND WE DO advise that the establishment of this Commission and your appointment as Commissioners hereunder is without prejudice to both the claim of the Government of Canada and the claim of the Government of Newfoundland to legislative jurisdiction and proprietary rights on or in respect of the Territorial Sea or the Continental Shelf off Newfoundland and Labrador;

AND FURTHER, not withstanding the terms of reference as set forth in this your Commission, We hereby direct you not to consider, comment upon nor make recommendations in respect of the claims to jurisdiction and rights aforesaid;

AND FURTHER, We do authorize

(i) the Honourable T. Alexander Hickman to be the Chairman of the Enquiry and the Honourable Gordon A. Winter to be Vice-Chairman of the said Enquiry;

(ii) the Chairman and Vice-Chairman, after consultation with the other Commissioners, to:

(A) adopt such practices and procedures for all purposes of the enquiry as may from time to time be necessary for the proper conduct of the enquiry and, may, after consultation with the other Commissioners, vary those practices and procedures from time to time;

(B) engage the services of counsel to aid and assist the Commissioners in the enquiry at such rates of

3. The Commissions be authorized to sit at such times and in such places, and to view such locations, both in and outside Canada, as the Chairman may, after consultation with the other Commissioners, from time to time decide; and

4. The Commissions be authorized to submit interim reports to the Governor in Council from time to time.

The Committee further advise that the Commissioners be directed to submit a final report to the Governor in Council with all reasonable dispatch and file with the Dominion Archivist the papers and records of the Commission as soon as reasonably may be after the conclusion of the Inquiry.

And the Committee further advise that pursuant to section 37 of the Judges Act, the Honourable T. Alexander Hickman be authorized to act as a Commissioner and Chairman for the purpose of the said Inquiry.

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CLERK OF THE PRIVY COUNCIL

remuneration and reimbursement as may be approved by the Lieutenant-Governor in Council;

(C) rent such space for offices and hearing rooms as they deem necessary and advisable at such rates as may be approved by the Lieutenant-Governor in Council;

(D) engage the services of such accountants, engineers, technical advisors or other experts, clerks, reporters and assistants as they may deem necessary or advisable, at such rates of remuneration and reimbursement as may be approved by the Lieutenant-Governor in Council;

(E) exercise all powers conferred upon them by Section 5 of The Public Enquiries Act;

(iii) you, the said Commissioners, to sit at such time and in such places, and to view such locations, both in and outside Canada, as the Chairman may, after consultation with the other Commissioners, from time to time decide;

(iv) you, the said Commissioners, to submit interim reports to the Lieutenant-Governor in Council from time to time.

AND WE DO, by these Presents, confer upon you, the said Commissioners, the power of summoning before you any witness or witnesses and of requiring all such witnesses to give evidence orally or in writing upon oath or upon solemn affirmation, and to produce such documents and things as you, the said Commissioners, may deem requisite to the full investigation of the matters you are appointed to enquire into.

AND FURTHER, We require you, with as little delay as possible to report to Us your findings upon the matters herein submitted for your consideration together with the papers and records of the Commission.

AND FURTHER, We do authorize the Honourable T. Alexander Hickman to act as a Commissioner and Chairman for the purpose of the said Enquiry, pursuant to Section 37 of The Judges Act.

IN TESTIMONY WHEREOF, We have caused these Our Letters to be made Patent and the Great Seal of Newfoundland to be hereunto affixed.

WITNESS: Our trusty and well-beloved the Honourable W. Anthony Paddon, Member of Our Order of Canada, Lieutenant-Governor in and for Our Province of Newfoundland.

AT OUR GOVERNMENT HOUSE in Our City of St. John's this *16th* day of *March* in the year of Our Lord one thousand nine hundred and eighty-two and in the thirty-first year of Our Reign.

BY COMMAND, Deputy REGISTRAR GENERAL

ITEM A-4

NOTICE INVITING SUBMISSIONS

Royal Commission on the *Ocean Ranger* Marine Disaster
Canada

Commission Royale sur le Désastre Marin de l'*Ocean Ranger*
Newfoundland / Terre-Neuve

NOTICE

Part One of the Commission's mandate establishes the Terms of Reference for the inquiry into the loss of the Ocean Ranger. The technical evidence arising from this investigation will be heard during the final phase of the public hearings that will resume in the fall.

Part Two instructs the Commission to inquire into "both the marine and drilling aspects of practices and procedures in respect of offshore drilling operations" off Eastern Canada. This inquiry, which is proceeding in parallel with the Part One investigation, will draw on three main sources of information: evidence given regarding the loss of the Ocean Ranger; the results of studies that are being undertaken for the Commission; and briefs or submissions presented to the Commission.

The Commission has set as its goal: to identify practical means of improving the safety of Eastern Canada offshore drilling operations. The studies directed towards this goal are being approached under four principal areas;

- Environment — evaluation of design and operations criteria dictated by the physical environment offshore;
- Design — the conception, design, construction, classification, certification and equipping of drilling units used in offshore operations;
- Safety — the elements of offshore drilling operations related to human safety including all aspects of safety of life at sea including rescue, occupational health and the certification and training of the marine and drilling crews;
- Regulation — the manner in which offshore drilling operations are controlled by rules, regulations and guidelines and their adequacy in relationship to safety.

The Commission invites knowledgeable people and organizations to make submissions addressed to this goal. Anyone wishing to make such a contribution to the Commission's work should do so in writing by December 31, 1983. Submissions should be sent to:

David M. Grenville
Commission Secretary
Royal Commission on the Ocean Ranger Marine Disaster
P. O. Box 2400
St. John's, Newfoundland
A1C 6G3

from whom further information about the form and scope of submissions can also be obtained.

Public hearings related to Part Two of the Commission's Terms of Reference will be held at a place and time to be announced.

ITEM A-5

REQUESTS FOR PARTICIPATION

In September, 1983, a Notice (Appendix A, Item 4) was placed in the national and regional press explaining the Royal Commission's Part Two Terms of Reference and requesting submissions relating to matters covered by that mandate. Subsequently, over a period of several weeks in late 1983 and early 1984, letters repeating this request for submissions were sent to approximately one hundred and fifty individuals and organizations judged to be potential respondents with an interest in the safety of eastern Canada offshore drilling operations. Enclosed with each letter were copies of: a statement made by the Chairman at the conclusion of the public hearings session on December 1, 1983; a Memorandum Inviting Submissions and attached Guidelines; and the Terms of Reference of the Commission. These documents are included in this appendix.

In view of the international nature of the industry, potentially interested organizations abroad were sent letters advising them in similar terms of the Royal Commission's interest in receiving submissions. This information was also sent to Canadian ambassadors in a number of countries.

Lists of the organizations contacted and of submissions received are included in this appendix, together with brief descriptions of selected submissions (Appendix A, Items 6, 7, and 8).

Royal Commission on the *Ocean Ranger* Marine Disaster
Canada

Commission Royale sur le Désastre Marin de l'*Ocean Ranger*
Newfoundland/Terre-Neuve

December 14, 1983

Dear

We believe that you will want to be informed of this Royal Commission's Part Two Inquiry and that you may wish to make a submission. The following are, therefore, enclosed herewith for your information:

- Statement by the Chairman at the conclusion of the public hearings session on December 1, 1983;
- Memorandum Inviting Submissions and attached Guidelines;
- Terms of Reference of the Commission.

If you plan to respond or have any questions, please let us know.

Yours very truly,

David M. Grenville
Commission Secretary

Commissioners/Commissaires

Chief Justice T. Alexander Hickman, Chairman/Président
The Honourable Gordon A. Winter, O.C., Vice Chairman/Vice Président
Finlan J. Aylward, Q.C.
Ian Furst, P. Eng.
M.O. Morgan, C.C.
N. Bruce Pardy, P. Eng.

Counsel/Counseiller Juridique

Leonard A. Martin, Q.C.
David B. Orsborn

Commission Secretary/Secrétaire de la Commission

David M. Grenville

Fort William Building **Edifice Fort William**
p.o. box/c.p. 2400 St. John's, Newfoundland/St. Jean, Terre-Neuve; A1C 6G3 · 709 · 772-4319, telex 016-4720

STATEMENT BY THE CHAIRMAN
THE HONOURABLE T. ALEXANDER HICKMAN
December 1, 1983

This Royal Commission, by its Terms of Reference, has been given two tasks: firstly, to find out, if possible, the probable cause of the loss of the *Ocean Ranger* and to identify anything that may have contributed to it; and secondly, to look at offshore drilling operations and determine how further marine disasters of this kind may be avoided in the future.

The first task, that of inquiring into the probable cause of the loss, has been our priority to this time. Because of the magnitude of the disaster and its implications for the continuing drilling operations off our shores, it was quite clear to us that a very thorough investigation must be conducted and all the relevant evidence that could be found made available for the public scrutiny of the Royal Commission and those appearing before it. Some important technical studies had also to be undertaken in order to achieve the clearest possible understanding of what probably happened and why. A diving examination of the *Ocean Ranger* was carried out for the Royal Commission and the rig was subsequently brought up from the sea floor and sunk again in deeper water, an operation that generated further information. All this investigatory and analytical work has been complex and time-consuming. It has been done as expeditiously as possible and it appears only some very technical evidence from professionals remains to be given.

A great deal of relevant evidence has been presented to this Commission over the past 13 months involving 72 sittings when 100 witnesses were heard whose testimony has been transcribed on 12,000 foolscap pages. What now remains is that the results of the technical investigation be submitted to us.

The next session, starting in late January should, therefore, bring to a conclusion what has been a very lengthy but necessary process. When this point is finally reached and the hearings are over, the Commission will be giving its most urgent attention to the analysis of all the evidence it has heard and to writing the final report on the loss, which will be submitted to the two governments. We expect to complete that task within four months from the end of the hearings.

Although the investigation of the loss in all its aspects has necessarily taken longer than expected we are determined that our work overall will be completed on time. While we have always been mindful of time schedules, our decision at an early stage was that no evidence would be ignored simply to meet the questionable expedient of an early report.

In recent months, we have been giving an increasing amount of attention to our second major task: the inquiry into safety of life offshore. A carefully planned program of studies has been launched over the past few months for the Royal Commission. It focuses on our current state of knowledge (or any gaps in it) with respect to: the physical environment in which drilling operations are taking place; the engineering design process; the interaction between people and machines in that environment; and lastly, how the whole activity is controlled.

The studies are being undertaken by knowledgeable individuals and organizations selected on the basis of the best advice we could obtain. We expect to have the results of this work available to us by next spring. Our intention is to make this information available to other experts in each field for review. These reports are being prepared for the Royal Commission, not by it. We are, therefore, anxious to ensure that the data and conclusions in them are well tested before we draw on them for our own findings.

A further step in the process of consultation will be an international conference which the Royal Commission is organizing in association with Memorial Uni-

versity of Newfoundland. It will be held here in St. John's on Memorial's campus between August 20 and 24, 1984, and will be the first of its kind to be held in Canada.

The conference will be a relatively small gathering of experts, and we shall be inviting a selection of the most knowledgeable people in this country and from the wider international community, who can contribute to the Royal Commission's work. We shall be looking to them to debate the results of the studies carried out for us. The conference will also provide a forum for discussion of the complex and serious issues which this Commission is addressing.

As soon as possible, after the conclusion of the conference, the concluding phase of our public hearings will begin. The results of the conference will be presented at these hearings and interested parties, including persons, groups or associations who wish to make final submissions to this Royal Commission, will have the opportunity to do so at that time. We envisage that the hearings next fall, following the conference, will be of a less formal nature. They will be governed by flexible procedures which will be appropriate to a Royal Commission considering broad policy issues.

This Royal Commission is unique in that it was established jointly by the Government of Canada and the Government of Newfoundland. We are, therefore, conscious that our mandate is national as well as regional. It has been right to conduct the investigation of the disaster here in Newfoundland, the home of so many of the crew of the *Ocean Ranger* and close to where the rig was lost. This is a matter of intense regional concern.

The safety of life in the drilling operations off Canada's East Coast is a matter of concern for all Canadians. It is our intention, therefore, to arrange public hearings of this Commission in other cities across the country where interest is expressed in having it appear. This international industry is one in which Canadians from every region are deeply involved. There are at present some 3,000 people working in drilling operations off Newfoundland and Labrador and close to 70 percent of them are Canadian. The total number will inevitably continue to grow as will the proportion of the offshore labour force that is Canadian.

Newfoundlanders have always been realists about the sea. Those who earn their living on it know that they face risks daily that are not present on land. The stretch of ocean from Lancaster Sound down to Georges Bank off Nova Scotia, 3,000 miles south, is one of the most hostile marine environments on this planet. Working offshore can, therefore, never be risk-free, but it is incumbent on us to reduce or, if possible, eliminate the avoidable risks. Some of these are relatively obvious and straightforward to deal with by more careful management. Other risks are concealed within a process which may be that of design, or construction, or operation; or a system may not reveal how vulnerable it is until an emergency arises.

It is always easier to correct a specific problem than to change the way we do things. We shall be seeking insights into how well these processes do in fact work; we shall be asking whether improvements can be introduced and how; we shall be looking for the best advice that is available. It is my hope that the outcome of our inquiry will be a contribution to the quality of management of this important activity. If this can be achieved, it will be with the help of operators and regulators and the participation of drilling and service contractors. We look forward to working over the year ahead with both government and industry towards this goal.

MEMORANDUM INVITING SUBMISSIONS

INTRODUCTION

The Royal Commission on the *Ocean Ranger* Marine Disaster was jointly established in March 1982 by the governments of Canada and Newfoundland. It has been given comprehensive Terms of Reference (enclosed herewith) which are divided into two parts.

Part One calls for a thorough investigation into the loss of the drill rig *Ocean Ranger* and all its crew. The Part One public hearings which commenced in October 1982, are expected to conclude early in 1984. The Royal Commission will then prepare its report on this first phase of the Inquiry and submit it to the Government of Canada and the Government of Newfoundland.

Part Two of the Royal Commission's Terms of Reference calls for it to inquire into, report upon, and make recommendations with respect to both the marine and drilling aspects of practices and procedures in respect of eastern Canada offshore drilling operations and to a number of specific matters relating to the safe operation of drilling units.

PART TWO PROCESS

The process being followed by the Royal Commission in respect of Part Two consists, initially, of conducting studies and calling for submissions related to the Terms of Reference. The purpose of the studies is to provide a concise but comprehensive statement of the state-of-the-art in the main areas of concern. Submissions will add to the information base on which the Commission will draw. This includes the conclusions of other inquiries, the *Alexander L. Kielland* Inquiry in Norway and the Burgoyne Committee on *Offshore Safety* in the United Kingdom, technical data gathered in the Part One Inquiry and a great deal of other material that has been made available from a variety of sources.

Papers will then be invited for presentation at an international consultative conference which the Commission will be organizing in association with Memorial University of Newfoundland. The conference, which is to be held in August 1984 in St. John's, will provide a forum for invited experts from government, industry, and the academic community to debate key issues related to safety in offshore drilling operations.

The Royal Commission will complete the Part Two process by holding informal public hearings following the conference. These hearings will afford interested parties and the general public an opportunity to make their concerns or comments known to the Commission prior to the preparation of the Commission's final report.

TERMS OF REFERENCE

The Royal Commission must, under Part Two of its Terms of Reference, inquire into, report upon, and make recommendations in respect to:

- The design, construction and stability of drilling units conducting marine and drilling operations off eastern Canada and their suitability to operate safely in that physical environment;
- Inspection, inspection procedures, licensing, classification, and certification of such drilling units;
- Safety of life at sea, including the sufficiency of lifesaving equipment on board those drilling units;
- Occupational health and safety relating to their officers and crews;

- The certification, training, and safety of those officers and crews and their respective responsibilities.

The Royal Commission must determine the adequacy, appropriateness and suitability, for eastern Canadian conditions, of the foregoing.

BASIC ISSUES

The Royal Commission needs factual information, views, and suggestions on matters covered by its Terms of Reference. This memorandum has been prepared to focus attention on the basic questions which must be addressed. The list does not purport to be exhaustive and those submitting briefs should not feel restrained from addressing other questions that lie within the terms of the inquiry.

To facilitate consideration of these issues, a number of basic questions have been identified:

Environment

- Environmental conditions offshore are key factors affecting the safe design and operation of drilling units operating off eastern Canada. These include forces generated by a combination of waves, wind, currents, icebergs, and pack ice, as well as sea state and sea bottom foundation conditions. Are the environmental data now available adequate in quality, quantity, and timeliness? Are the methods of detection, prediction, and interpretation adequate to the need?

Design

- Is the philosophy and process for the design of the basic structure and of systems critical to the safe year-round operation of mobile offshore drilling units (MODUs) adequately defined and followed? Are changes needed in design or operational procedures for such critical systems?
- Are the rules applied and the procedures followed with respect to MODU design, construction, licensing, and operation adequate and effective and do these adequately ensure continuity of engineering responsibility?

Safety and Training

- What is an acceptable safety standard and risk level for offshore exploratory drilling?
- What measures are required to improve all aspects of occupational health and safety on MODUs? Is health care response adequate in the event of an offshore emergency?
- Are the standards adequate for marine and emergency training of all personnel engaged in offshore exploratory drilling? Are the methods used effective and how is this determined? Are key industrial and marine personnel on MODUs adequately trained for emergency conditions? How is this determined?
- Is the command and organizational structure on MODUs able to produce an effective response to emergencies?
- How can evacuation, survival, and rescue techniques be improved? What improvements are required in the search and rescue capability of both government and industry to cope with a major marine disaster off eastern Canada?

Regulations

- For eastern Canada offshore, what combination of government and industry control produces the most effective regulatory regime to ensure that human safety is maintained? What method of regulation is most effective?
- How can the administration and management of the government and industry control structure be improved?

SUBMISSIONS

A response to these issues must be directed towards the Royal Commission's goal in Part Two, which is to identify practical means of improving the safety of eastern Canada offshore drilling operations. A Notice was published in newspapers across the country at the beginning of September inviting knowledgeable people and organizations to make submissions related to the Commission's goal. This Notice is attached, together with the "Guidelines for Submissions Related to Part Two of the Royal Commission's Terms of Reference."

GUIDELINES FOR SUBMISSIONS

INTERESTED PARTIES

The Royal Commission is seeking submissions from knowledgeable people and organizations with a direct and substantial interest in any matters that are covered by Part Two of its Terms of Reference. The preparation of a submission will entail no obligation to present it subsequently in public, nor will interested parties be obliged to appear at hearings of the Royal Commission. They may, of course, ask to appear before the Commission if they wish to be heard.

FUNDING

The Royal Commission's mandate does not cover the funding of research and development activity in areas related to the Inquiry. It cannot therefore respond to unsolicited proposals for R & D projects, or to requests for reimbursement of costs incurred in preparing submissions.

SCOPE

The Royal Commission is interested in receiving from interested parties factual information, opinions, and suggestions that are directed towards identifying practical means of improving the safety of eastern Canada offshore drilling operations. The scope of a submission may therefore be limited to a particular aspect of any matter covered by the mandate of the Commission, or it may address a broad range of issues. It should avoid the promotion of products or services.

FORM

Submissions should be in writing and typewritten, if possible, on 216 mm x 279 mm (8½" x 11") paper. It would be helpful, although it is not essential, if ten copies of each submission could be provided.

TIMING

The Royal Commission is working to a firm schedule. It intends to complete the consultative process related to Part Two of its mandate by the fall of 1984 so that it may complete its final report by early 1985. Accordingly, any interested party wishing to make a submission should do so as a matter of urgency so that it may receive due consideration. The Notice published by the Commission in early September set a deadline of December 31, 1983 for receipt of submissions. This has been extended to March 31, 1984, by which date the investigation and public hearings related to the loss of the *Ocean Ranger* are expected to be over.

ITEM A-6

INDIVIDUALS AND ORGANIZATIONS CONTACTED FOR SUBMISSIONS

AIG Oil Rig, Inc.
New York, New York, USA

Aker Engineering A/S
Oslo, Norway

American Bureau of Shipping
New York, New York, USA

Association of Professional Engineers
of New Brunswick
Fredericton, New Brunswick

Association of Professional Engineers
of Newfoundland
St. John's, Newfoundland

Association of Professional Engineers
of Nova Scotia
Halifax, Nova Scotia

Association of Professional Engineers
of Prince Edward Island
Charlottetown, Prince Edward Island

Bedford Institute of Oceanography
Dartmouth, Nova Scotia

Blake, Cassels & Graydon
Barristers & Solicitors
Toronto, Ontario

Bouygues Offshore
Le-Plessis-Robinson, France

Bow Valley Resource Services Limited
Calgary, Alberta

BP Exploration Canada Limited
Calgary, Alberta
St. John's, Newfoundland

British Columbia Institute of Technology
Burnaby, British Columbia

Bureau Veritas
Montreal, Quebec

Canadian Association of Diving Contractors
North Vancouver, British Columbia

Canadian Association of Oilwell
Drilling Contractors
Calgary, Alberta

Canadian Council of Professional Engineers
Ottawa, Ontario

Canadian Drilling Research Association
Calgary, Alberta

Canadian Federation of Labour
Ottawa, Ontario

Canadian Guild of Commercial Divers
St. Catharines, Ontario

Canadian Institute of Marine Engineers
Ottawa, Ontario

Canadian Ocean Industries Association
Halifax, Nova Scotia

Canadian Offshore Vessel Operators
Association
Halifax, Nova Scotia

Canadian Petroleum Association
Offshore Operators Division
Calgary, Alberta
Halifax, Nova Scotia
St. John's, Newfoundland

Canadian Society of Safety Engineers
Rexdale, Ontario
St. John's, Newfoundland

Canadian Standards Association
Rexdale, Ontario

Canadian Transport Commission
Hull, Quebec

Canadian Welding Bureau
Toronto, Ontario

Canterra Energy Limited
Calgary, Alberta

Carson, Professor W.G.
La Trobe University
Melbourne, Victoria
Australia

Centre for Cold Ocean Resources
Engineering
St. John's, Newfoundland

Chalker, Green & Rowe
Barristers & Solicitors
St. John's, Newfoundland

Chevron Canada Resources Limited
Calgary, Alberta

Chevron Standard Limited
Calgary, Alberta

College of Fisheries, Navigation,
Marine Engineering & Electronics
St. John's, Newfoundland

College of Trades & Technology
St. John's, Newfoundland

Comex S.A.
Marseille, France

Commission des Communautés
européennes
Bruxelles, Belgium

Dome Petroleum Limited
Calgary, Alberta

Downey, Dr. J.
University of New Brunswick
Fredericton, New Brunswick

Dyvi Offshore A/S
Oslo, Norway

E & P Forum
(The Oil Industry International
Exploration & Production Forum)
London, England

EMPRA Systems Corporation
Vancouver, British Columbia

EPI Resources Limited
Calgary, Alberta

Esso Resources Canada Limited
Calgary, Alberta

General Council of British Shipping
London, England

General Research & Development Limited
Kilbride, Newfoundland

Geological Association of Canada
St. John's, Newfoundland

Germanischer Lloyd
Hamburg, West Germany

Götaverken Arendal AB
Göteborg, Sweden

Götaverken Arendal Canada Limited
Halifax, Nova Scotia

Greenland Technical Organization
Copenhagen, Denmark

Gulf Canada Resources Inc.
Calgary, Alberta

Halifax Board of Trade
Halifax, Nova Scotia

Halley, Hunt
Barristers & Solicitors
St. John's, Newfoundland

Harvey Offshore Services Limited
St. John's, Newfoundland

Highlands and Islands Development Board
Inverness, Scotland

Hollobone, Hibbert & Associates Limited
London, England

Home Oil Company Limited
Calgary, Alberta

House Committee on Merchant Marine
& Fisheries
U.S. House of Representatives
Washington, D.C., USA

Husky Marine Services
St. John's, Newfoundland

Husky Oil Limited
Calgary, Alberta

Institut Français du Pétrole
Rueil Malmaison, France

International Association of Drilling
Contractors
Houston, Texas, USA

International Maritime Organization
London, England

Kirlin, Campbell & Keating
Attorneys at Law
New York, New York, USA

Kuo, Dr. Chengi
University of Strathclyde
Glasgow, Scotland

Kvaerner Industrier
Oslo, Norway

Lemle, Kelleher, Kohlmeyer & Matthews
Attorneys at Law
New Orleans, Louisiana, USA

Lloyd's Register of Shipping
London, England
Montreal, Quebec

M & M Protection Consultants
New York, New York, USA

MacDonald, Sheriff Alistair
Lerwick, Shetland

Maersk Company Limited
London, England

Martin, Whalen, Hennebury & Stamp
Barristers & Solicitors
St. John's, Newfoundland

Meincke, Dr. P.M.
University of Prince Edward Island
Charlottetown, Prince Edward Island

deMestral, Professor A.L.C.
McGill University
Montreal, Quebec

Memorial University of Newfoundland
St. John's, Newfoundland

Mineral Resources Administration
Government of Denmark
Copenhagen, Denmark

Mobil Oil Canada Limited
Toronto, Ontario

National Ocean Industries Association
Washington, D.C., USA

National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Washington, D.C., USA

National Research Council of Canada
Ottawa, Ontario

National Transportation Safety Board
Washington, D.C., USA

New Brunswick Federation of Labour
Newcastle, New Brunswick

New Brunswick Research & Productivity Council
Fredericton, New Brunswick

New Brunswick Safety Council Inc.
Fredericton, New Brunswick

Newfoundland & Labrador Federation of Labour
St. John's, Newfoundland

Newfoundland Ocean Industries Association
St. John's, Newfoundland

Newfoundland Safety Council
St. John's, Newfoundland

Nippon Kaiji Kyokai
Tokyo, Japan

NOHAB Verkstads AB
Trollhatten, Sweden

Norsk Offshore Forening
Oslo, Norway

North Atlantic Contractors
St. John's, Newfoundland

North Star Fishing Company Limited
Aberdeen, Scotland

Norwegian Hydrodynamic Laboratories
Trondheim, Norway

Norwegian Offshore Operators Association
Stavanger, Norway

Norwegian Petroleum Consultants A.S.
Nesbru, Norway

Norwegian Petroleum Directorate
Stavanger, Norway

Nova Scotia Department of Mines & Energy
Halifax, Nova Scotia

Nova Scotia Federation of Labour
Halifax, Nova Scotia

Nova Scotia Institute of Technology
Halifax, Nova Scotia

Nova Scotia Nautical Institute
Halifax, Nova Scotia

Nova Scotia Research Foundation Corporation
Dartmouth, Nova Scotia

Nova Scotia Safety Council
Halifax, Nova Scotia

Ocean Drilling & Exploration Company
New Orleans, Louisiana, USA

Ocean Inchcape (Shetland) Limited
Lerwick, Shetland

Ocean Ranger Families Foundation
St. John's, Newfoundland

Offshore Survey (Overseas) Limited
Stroud, Gloucester

O'Keefe, R.T.
Rosemere, Quebec

O'Neill, O'Reilly & Noseworthy
Barristers & Solicitors
St. John's, Newfoundland

OTTER Group
Trondheim, Norway

Ozmon, Dr. K.L.
Saint Mary's University
Halifax, Nova Scotia

Petro-Canada Resources
Calgary, Alberta

Petroleum Industry Training Board
Offshore Training Centre
Angus, Scotland

Petroleum Industry Training Service
Calgary, Alberta

Petroleum Services Association of Canada
Calgary, Alberta

Phillips Petroleum Company Europe-Africa
London, England

Prince Edward Island Federation of Labour
Charlottetown, Prince Edward Island

Rauma-Repola OY
Mäntyluoto Works
Pori, Finland

Registro Italiano Navale
Genoa, Italy

Robert Gordon's Institute of Technology
Offshore Survival Centre
Aberdeen, Scotland

Science Council of Canada
Ottawa, Ontario

Seaforth Fednav Inc.
Halifax, Nova Scotia

Sealand Helicopters
St. John's, Newfoundland

Secretariat for Safety & Working
Environment Offshore
Royal Ministry of Local Government
& Labour
Oslo, Norway

SEDCO, Inc.
Dallas, Texas, USA

Serdula Systems Limited
Deep River, Ontario

Shell Canada Resources Limited
Calgary, Alberta

Shell UK Exploration & Production
Aberdeen, Scotland

Shetland Islands Council
Lerwick, Shetland

Ship Research Institute of Norway
Oslo, Norway

Society of Naval Architects
& Marine Engineers
Halifax, Nova Scotia

Spar Aerospace Limited
Weston, Ontario

SPIE Offshore
La Boursidière, France

St. John's Board of Trade
St. John's, Newfoundland

Stewart, MacKeen & Covert
Barristers & Solicitors
Halifax, Nova Scotia

Stirling, Ryan
Barristers & Solicitors
St. John's, Newfoundland

Technica Limited
London, England

Technical University of Nova Scotia
Halifax, Nova Scotia

Techwest Enterprises Limited
Vancouver, British Columbia

Texaco Canada Resources Limited
Calgary, Alberta

U.K. Offshore Operators Association
London, England

United Kingdom Department of Energy
Petroleum Engineering Division, Branch 5
London, England

Union des Industries de la
Communauté européenne
Bruxelles, Belgium

United States Coast Guard
Cleveland, Ohio, USA
Washington, D.C., USA

Universal Helicopters (Nfld.) Limited
St. John's, Newfoundland

Universal Industrial Service
& Manufacturers Limited
Mississauga, Ontario

von Tell Nicoverken AB
Göteborg, Sweden

WADAM Helsinki Shipyard
Helsinki, Finland

Work Research Institute
Oslo, Norway

Workers' Compensation Board
Charlottetown, Prince Edward Island

Workers' Compensation Board
Halifax, Nova Scotia

Workers' Compensation Board
Saint John, New Brunswick

Workers' Compensation Board
St. John's, Newfoundland

Zapata Offshore Company
Houston, Texas, USA

ITEM A-7

RESPONSES FROM INDIVIDUALS AND ORGANIZATIONS

Italics indicate submissions summarized in Appendix A, Item 8.

Association of Professional Engineers of Newfoundland
St. John's, Newfoundland

Budgell, Ronald
St. John's, Newfoundland

Canadian Association of Diving Contractors
Willowdale, Ontario

Canadian Petroleum Association
Offshore Operators Division
St. John's, Newfoundland

Company of Master Mariners of Canada
Dartmouth, Nova Scotia

Crosbie Offshore Services Limited
St. John's, Newfoundland

Dalton, Frank
St. John's, Newfoundland

Demerais, Brett
Surrey, British Columbia

Dome Petroleum Limited
Calgary, Alberta

E & P Forum
(The Oil Industry International Exploration & Production Forum)
London, England

Eastern Technical Services
St. John's, Newfoundland

Elms, Clarence
Harbour Grace, Newfoundland

Fleming, W.
Dartmouth, Nova Scotia

General Research & Development
Kilbride, Newfoundland

Ginge Kerr Canada Limited
Point Claire, Quebec

Götaverken Arendal AB
Göteborg, Sweden

Harvey Offshore Services Limited
St. John's, Newfoundland

Husky Marine Services
St. John's, Newfoundland

Inch, James R.
Glace Bay, Nova Scotia

Inter-Church Commission on the Social Impact of Resource Development
St. John's, Newfoundland

Intercontinental Marine Limited
Gibsons, British Columbia

International Association of Drilling Contractors
Houston, Texas, USA

Kuo, Dr. Chengi
University of Strathclyde
Glasgow, Scotland

Montague, George W.
St. John's, Newfoundland

National Oceanic and Atmospheric Administration
Washington, D.C., USA

National Research Council of Canada
St. John's, Newfoundland

Newfoundland and Labrador Federation of Labour
St. John's, Newfoundland

Norwegian Hydrodynamic Laboratories and Norwegian Institute of Technology
Trondheim, Norway

Norwegian Hydrodynamic Laboratories
Trondheim, Norway/
National Research Council of Canada
Ottawa, Ontario

Ocean Ranger Families Foundation
St. John's, Newfoundland

Offshore Surveys (Overseas) Limited
Stroud, Gloucester

Petro-Canada Inc.
St. John's, Newfoundland

Petro-Canada Resources
Calgary, Alberta

Petroleum Industry Training Service
Calgary, Alberta

Ship Research Institute of Norway
Trondheim, Norway

Simard, Bernard
Montreal, Quebec

Sunter, Samuel Thomas
Victoria, British Columbia

Technica Limited
London, England

United Kingdom Offshore Operators Association
London, England

Wilderness Society of Newfoundland & Labrador
St. John's, Newfoundland

Yungblut, Glen R.
EPI Resources Limited
Ottawa, Ontario

ITEM A-8

SUMMARIES OF SELECTED SUBMISSIONS

The following submissions were selected for description:

1. Association of Professional Engineers of Newfoundland
2. Canadian Association of Diving Contractors
3. Harvey Offshore Services Limited
4. Inter-Church Commission on the Social Impact of Resource Development
5. Dr. Chengi Kuo
6. Newfoundland and Labrador Federation of Labour
7. Norwegian Hydrodynamic Laboratories and Norwegian Institute of Technology
8. *Ocean Ranger* Families Foundation
9. Petro-Canada Resources
10. Petroleum Industry Training Service
11. Glen R. Yungblut

ASSOCIATION OF PROFESSIONAL ENGINEERS OF NEWFOUNDLAND

Submitted March 22, 1984

The key purpose of the Association of Professional Engineers of Newfoundland (APEN) is the maintenance of professional standards which ensure safety in engineering design and construction practices. APEN does not differentiate between offshore and onshore engineering practices and for federal and provincial offshore regulations recommended that:

1. All persons carrying out professional engineering work onshore or offshore for oil-related activity, as defined in the various provincial acts, be obligated to register with the geographically linked provincial professional engineering association.
2. All companies carrying out professional engineering work onshore or offshore for oil- and gas-related activities, whether operators or owners of drilling rigs, platforms or ancillary equipment, be obligated to obtain a Certificate of Authorization from the geographically linked provincial professional engineering association.
3. All documents for engineering modifications to drilling and production units carried out in Canada be sealed by a professional member of the applicable provincial professional engineering association.
4. All engineering documents for drilling rigs, platforms, components, and ancillary equipment designed and/or constructed in Canada be sealed by a professional member of the applicable provincial professional engineering association.
5. Inspection of modifications and construction work carried out in Canada be under the direction of a professional member of the applicable provincial engineering association.

These recommendations also have the endorsement of the Associations of Professional Engineers of New Brunswick, Nova Scotia, and Prince Edward Island. APEN has indicated that its Council is evaluating a proposal to request that the Association's enabling legislation be amended to apply also to the continental margin adjacent to the province.

CANADIAN ASSOCIATION OF DIVING CONTRACTORS

Submitted September 21, 1984

The Canadian Association of Diving Contractors' (CADC) brief draws attention to the Diving Research Facility located at the Defence and Civil Institute of Environmental Medicine (DCIEM) in Downsview, Ontario. It notes that this facility was originally established to respond to operational diving requirements as identified by the Commander, Maritime Command, as well as to initiate diving research and development programs to meet present and future operational requirements of the Canadian Forces. The Canadian Forces also designated the HMCS *Cormorant*, a stern ramp trawler, to fulfill the role of a fleet diving support ship. The brief suggested that the utilization of the Diving Research Facility and the fleet diving support ship has been severely limited by three factors:

1. Economic constraints limiting the *Cormorant* to submersible atmospheric diving and surface-supplied diving;
2. Absence of a National Oceans Policy;
3. Absence of a Canadian Forces Deep-Diving Policy.

CADC recommends that the DCIEM facility address current national research and development requirements in support of the offshore subsea industry, assist with the identification of long-term R & D requirements in preparation for the production phases of Canada's offshore natural resources, and integrate its programs with similar international R & D establishments in order to avoid duplication and remain cost effective.

To facilitate the efficient operation of the DCIEM Diving Research Facility, CADC suggests that a Board of Directors and a management team be formed from the various disciplines associated with the subsea industry and appropriate government agencies. The CADC would be willing to sit as a member of this Board of Directors. Beyond some initial government funding, the DCIEM facility should be managed in an entrepreneurial, cost-efficient fashion with a review every five years to debate its continuance.

A follow-up letter to the brief describes the areas related to safety and other research and development programs which CADC sees the DCIEM facility performing. This would include research into:

- Composition, purity, and standards for divers' breathing mixtures;
- Use of decompression tables including the development of an abortive decompression table for dire emergencies;
- Physiological effects on the diver and mechanical problems of equipment used in extremely cold water;
- Biomedical and physiological effects of deep-diving programs.

In addition, the DCIEM facility would be available to perform diving medical contingency services.

[Editor's Note: On February 25, 1985, DCIEM submitted a response to the CADC brief to clarify statements made in that brief regarding the role of DCIEM's Diving Research Facility. DCIEM maintains that its underwater R & D programs are well established and recognized internationally. Notable advances have been made, by DCIEM, in decompression and thermal physiology, in life-support system development and in hyperbaric medicine. Furthermore, DCIEM supports the development of Canadian Diving Standards and has ongoing research programs in the areas identified in the CADC brief.]

HARVEY OFFSHORE SERVICES LIMITED

Submitted April 19, 1984
Adrian Coady

A two-part brief was submitted; the first part a summary of statistics for the employment of Canadian personnel on three MODUs in 1983. Overall observations were that significant development has occurred in the drilling and marine skills of the local work force and that there is a sufficient supply of personnel with lower and intermediate levels of skill such as roustabouts and crane operators respectively.

The second part of the brief gives an overview of Harvey's involvement with offshore drilling and provides a summary of the availability of MODU and support vessel staff. The following factors relevant to offshore employment were commented on:

1. Employee benefits packages play an important role in maintaining high morale and reducing turnover. Some suggested components would be salary continuance, basic life insurance, completion bonuses, and weekly pay schedules. Delivery of such benefits is, to a great degree, the responsibility of the employer and should be a factor in the awarding of contracts.
2. The work rotation configurations can be a risk factor and have a detrimental effect on good family relations. Support vessel rotations should be examined since supply vessel operators have carried a single crew for periods in excess of one hundred days.
3. There must be a minimum medical standard which incorporates stress tolerance levels in the personality profile. MODUs should have minimum standardized hospital equipment and drugs. On the whole, medical support of East Coast MODUs is adequate.
4. The accident rate follows industry norms and the reporting of accidents and injuries is adequate through current mediums.
5. The industry must set the standard in training since operators have the ultimate responsibility. Preboarding safety training must be developed in accordance with the needs of MODU operators.
6. Boarding orientation is strongly endorsed for all new personnel.

More specific recommendations on training noted that:

1. A floorman's course should be developed in the region;

2. A certificated standard of competence should be developed for crane operators on floating structures;
3. Derrickmen should have intermediate well control training and some consideration should be given to extending such training to at least the lead floorman.

In commenting on Affirmative Action Programs, it was recommended that more consultation at the local level would better identify the actual repercussions of such policies. The spirit of preferential hiring policies was endorsed but regulators do not research job qualification levels and duties prior to requiring operators to apply the policies. Such policies, however, have not jeopardized safety and operational efficiency. On the subject of regulation, the brief states that classification societies must carry the burden of establishing and maintaining quality of MODU design and construction. The guideline approach to regulation of the industry was recommended.

INTER-CHURCH COMMISSION ON THE SOCIAL IMPACT OF RESOURCE DEVELOPMENT

Submitted November 12, 1984

The Inter-Church Commission on the Social Impact of Resource Development was appointed in 1981. Its current members are representatives of the Anglican, Roman Catholic and United Churches and the Salvation Army. The purpose of the Commission is to provide a means whereby interested churches can work together in the community and speak out in respect of resource development policy. The Commission made three main recommendations:
1. That adequate search and rescue facilities be placed on Newfoundland's East Coast;
2. That the federal government take immediate action to legislate an Act regarding offshore safety;
3. That the government take initiatives to ensure that there is some form of worker participation in decision making related to matters affecting safety on board rigs. The minimum should be designating a safety representative and setting up an independant grievance procedure to protect workers.

DR. CHENGI KUO

Submitted November 7, 1984
Dr. Chengi Kuo
University of Strathclyde

Views on Problems and Practical Suggestions for Improving the Safety of Eastern Canadian Offshore Drilling Operations

The brief dealt with three main issues; MODU designs for the East Coast offshore, identification of the most urgent technical problems requiring practical solutions, and regulations to balance commercial interests with the need to protect human life. It suggested that operators and companies should be encouraged to start producing designs for MODUs specially intended for operation in the waters of eastern Canada, or at least ensure that modifications applied to replacement vessels should bring them as close as possible to the standard of a purpose-built vessel. MODUs for use in eastern Canadian offshore waters should meet the following design requirements:

1. Sufficient structural strength to cope with the hostile environmental conditions;
2. Stability not only in the intact but also in the listed condition, whether this is brought about by damage, incorrect ballasting, or any other cause;
3. Effective stationing arrangements using dynamic-positioning systems, with or without additional mooring;
4. A payload capacity sufficient to keep supply runs to a minimum.

Professor Kuo considers the most urgent problems requiring attention to be:

1. The development of a logical procedure for assessing the design and construction of MODUs for use in eastern Canadian offshore waters. The right configuration to meet the hostile environmental conditions needs to be identified.
2. The establishment of effective methods for calculating the stability of listed semisubmersibles, taking into account the effects of wind, waves, current, and ice-loading.
3. The development of reliable methods of positioning a vessel in offshore locations. In particular, a careful study is needed of the requirements if dynamic positioning is to be used when icebergs are present. The use of combined dynamic positioning and mooring arrangements for normal working environments also calls for examination.
4. The establishment, in conjunction with the classification societies, of the structural strength requirement for MODUs for use in eastern Canadian offshore waters, and a practical procedure for their construction.
5. The determination of a level of safety standard which can systematically use theoretical advances as they become available, practical experience, the results of experiments and whatever quantity of operational information is at hand.

The brief recommended that a strategy be devised to anticipate MODU design needs in steps of two, four, six, eight, and ten years. Sources of key missing information or expertise should be clearly identified and positive steps taken to acquire them. Regulations should then be established for the design of special purpose MODUs for eastern Canada using state-of-the-art knowledge.

NEWFOUNDLAND AND LABRADOR FEDERATION OF LABOUR

Submitted November 5, 1984
William Parsons
Frank Taylor
Don Taylor
 Newfoundland and Labrador
 Federation of Labour
Martin Saunders
 Canadian Labour Congress

In the Public Hearings held November 5, 1984, Mr. Parsons presented the brief of the Newfoundland and Labrador Federation of Labour containing the following recommendations:

WORKER HEALTH AND SAFETY

1. The Canadian authorities should take the steps necessary to ensure that the norms of Canadian law and regulation in matters of occupational health and safety are applied in the offshore petroleum industry. To this end the Government of Canada should proclaim without delay the amendments passed by Parliament to the *Canada Labour Code*, and in particular, to Part IV of the *Code* which deals with health and safety.
2. The Canadian authorities should draft, without delay, regulations under Part IV which will ensure that the normal principles and practices of occupational health and safety in Canada will be observed and enforced on offshore units.
3. In the event that authority over these matters is delegated to a province or provinces, the authorities should ensure that the principles embodied in 1 and 2 above are reflected in the relevant legislation and regulations.
4. Such regulations should be drafted after consultation with the industry, with the Canadian Labour Congress and with the Canadian Centre for Occupational Health and Safety.
5. Regulations applicable to the offshore should include:

- Access to private meeting places on board rigs for employee members of health and safety committees;
- Provision for the establishment and operation of regional or field committees to deal with matters affecting more than one rig in a field;
- Representation at the advisory council or commission level for management and unions from the offshore petroleum industry.

6. Regulations should include standards of qualification for rig medics, and should provide for their independence, in matters within their competence, from pressure or interference by rig management or other persons.
7. Regulations should make rig medics responsible for maintaining records of all occupational injuries and illnesses and for reporting these data to the relevant authorities.
8. Regulations should set standards for onboard sick bays.
9. Regulations should provide for the close availability of a decompression unit wherever divers are employed.
10. Regulations should provide for the earliest practicable access by a sick or injured employee to medical examination and treatment by the doctor of his or her choice.
11. The authorities should provide for the systematic accumulation, analysis and public reporting of personal occupational illness statistics for the industry. Every report of an occupational injury or illness should show, in addition to other relevant factors, the occupation of the victim and the suspected or determined cause of the injury or illness.
12. Information on rig hazards and preventative measures discovered by joint health and safety committees should be collected, analyzed and disseminated by the authorities.
13. Canada should co-operate with other countries in the development of common systems for the reporting of occupational safety and health data.

Union Representation

14. The Canadian authorities should take the steps necessary to ensure that the norms of Canadian law and regulation in matters of worker representation are applied in the offshore petroleum industry. To this end the Government of Canada should proclaim, without delay, the amendments passed by Parliament to the *Canada Labour Code*.
15. The Canadian authorities should draft, without delay, regulations which will ensure that the normal principles and practices of worker representation and trade union rights in Canada will be observed and enforced on offshore units.
16. In the event that authority over these matters is delegated, as permitted by law, to a province or provinces, the authorities should ensure that the principles embodied in 14 and 15 above are reflected in the relevant legislation and regulations.
17. Regulations applicable to the offshore should include provisions for:

- Regular access by union representatives to their members on board the rigs;
- Access to onboard facilities for private meetings of union members and officers;
- Access to private radio communications

to and from the shore by union officers on board rigs;
- Access by representatives of *bona fide* trade unions to information contained in employment registers concerning the names, shore addresses, employers, and occupations of offshore employees on a rig-by-rig basis.

18. Regulations should make provision for bargaining units, at the option of the union or unions concerned, to consist of:
- All bargaining unit employees of a single employer on an individual rig; or
- All bargaining unit employees of more than one employer on an individual rig; or
- Either of the above on more than one rig.

19. Regulations should provide for representation of more than one employer by a council of employers for the purposes of collective bargaining in cases where more than one employer is involved.

General

20. Regulations dealing with employment standards should incorporate rules which will facilitate the employment of female workers in the offshore industry.

21. The establishment of onshore norms and standards for the offshore, and the improvements required for the safe design, operation and (when necessary) evacuation of offshore units will involve amendments and the addition of regulations in a number of existing laws including the *Canada Shipping Act* and the *Canada Labour Code*. Except where undue delay would be occasioned, these alterations should be accomplished by the passage of an omnibus Canadian Continental Shelf bill in order to ensure broad consistency among different statutes.

22. Inspection and administration of the various laws and regulations applicable to the offshore industry, should be carried out in each case by representatives of the ministry, department or agency normally responsible, except that such bodies may be permitted to delegate portions of such responsibilities to each other in order to avoid unnecessary duplication, provided the quality of inspection or administration is not thereby impaired.

A SAFETY OFFSHORE INSTITUTE

The Federation proposes the creation of a safety institute for the offshore and urges the Royal Commission to make a supporting recommendation in its Part Two Report. In the aftermath of the *Ocean Ranger* disaster, a great deal of valuable information has been gathered. The technical assessments and investigations of the events surrounding the loss of the rig and the testimony of many witnesses have contributed to the store of data. Obviously, much remains to be done, both through lawmaking and technology, before we can be satisfied with the state of safety offshore. Canada has the opportunity to place itself among the leaders in the search for offshore safety, and Canada can apply such advances in the fishing industry as well as in petroleum.

Here again, Norway provides an admirable model in Sikkerhet pa Sokkelen (SPS), which translates into English as Safety Offshore. Safety Offshore is Norway's largest civil research project. Its budget of $16 million is contributed 57 percent by government and 43 percent by the offshore industry. It directs and funds research into offshore safety in consultation with a large number of participating organizations and institutions which include government, offshore operators, contractors, research bodies, unions, shipping companies, Det norske Veritas (Norway's classification society), industrial and employers' organizations, engineering companies, insurance companies, and manufacturers and vendors of offshore equipment. Safety Offshore will henceforth be responsible for the direction of all offshore safety research in Norway, and Norway, we should remind ourselves, is a country of only about four million people.

The proposal for a Safety Offshore Institute departs in some ways from the Norwegian model and involves the following elements:

Funding:
- By government with the assistance of the industry through a negotiated levy.

Participating Groups:
- Federal and relevant provincial governments;
- RCC, SAREC and Canadian Coast Guard;
- The offshore industry;
- Labour;
- Universities and trades training institutions in the offshore provinces;
- The *Ocean Ranger* Families Foundation;
- Representatives of management and labour from the fishing industry;
- The Canadian Centre for Occupational Health and Safety.

Policy and Priorities

The day-to-day policies of the Institute would be guided by a representative Board of Governors and a smaller executive committee, none of whom would be employed by the Institute. The members of the Board would be appointed and serve at the pleasure of the Government of Canada.

Management:
- By a full-time director general.

Areas of Concern:

1. Research into safety offshore in the broad sense, including rig safety, evacuation methods and technologies, ergonomics, occupational safety and health and medical research;
2. Collection, analysis and dissemination of statistics and information arising from research;
3. Design and delivery, or supervision of courses for the offshore, including basic safety training and pre-employment orientation for crews of drilling units; specialized certificate courses for stability and ballast control officers, masters, lifeboat crews and crews of helicopters and standby vessels; and other special courses for industry field managers;
4. Advice in the design of occupational training courses for offshore employment.

The Institute would perform its work both through its in-house capabilities and by commissioning projects to universities or other research, training, or consulting specialists.

Initial Composition

Some of the elements essential to the success of the institution are nearby. The Royal Commission's own Information Centre in St. John's and the associated administrative staff would provide the Offshore Safety Institute with a running start. The Newfoundland Petroleum Directorate, whose capabilities have been enhanced since the *Ocean Ranger* disaster, would provide another immediately useful component.

Collaborating Bodies

The Engineering Department of Memorial University has performed valuable work for the Royal Commission and would, presumably, be able to undertake additional tasks related to offshore safety given appropriate assistance from the Institute. No doubt there are resources available in other parts of Atlantic Canada that could also be tapped for these purposes. The Federation envisages the Offshore Safety Institute also collaborating with both government-sponsored and private institutions in the United States, the United Kingdom, Norway, and other countries which have a stake in the offshore petroleum industry.

Under questioning from the Commission Chairman four other points from the written brief were elaborated upon and clarified:
1. Canadian Centre for Occupational Health and Safety: A centre located in Hamilton, Ontario which collects data on occupational health and safety. When its data is processed the Centre then provides the assurance to all users that it is the most up-to-date and factual information available.
2. Charlie Report: A compilation of accident statistics collected on an entirely voluntary basis by an organization of U.S. drilling contractors. The report was referred to simply as a demonstration of how spotty and unsystematic the collection of these statistics is.
3. Guidelines/Regulations: No industry should be permitted to exercise independent authority since situations must inevitably be confronted that require choice between safety and production. Further to this, the Federation contends that this industry has demonstrated that it is not competent to regulate itself and that there should be a very strong regulatory system set up.
4. Offshore Safety Institute: The Institute as envisaged by the Federation would link together the various institutions which are involved to ensure agreement on the standards to be observed in training courses. The Institute would then issue the necessary certificates. This body would provide a consultative medium and also certification and training, although it would not duplicate talents and expertise available elsewhere.

In closing, Mr. Parsons stated that the Federation is asking that there be worker participation in respect to any regulation or legislation on the offshore.

NORWEGIAN HYDRODYNAMIC LABORATORIES and NORWEGIAN INSTITUTE OF TECHNOLOGY

Submitted March 9, 1983
Erling Huse
Norwegian Hydrodynamic Laboratories
Torgeir Moan
Norwegian Institute of Technology

Brief Comments on the Part II Inquiry;
Safety of Offshore Structures;
New Norwegian Regulations for Mobile Offshore Units – Safety Philosophy;
Notes on Stability Regulations for Mobile Platforms

There are two regulatory approaches that can be taken to ensure the safety of MODUs; the use of specific criteria which are applied to all units, or a functional approach whereby each unit is assessed to determine the level of risk. Due to the complexity of the design and operational considerations involved, the only rational functional approach is a systematic risk analysis based on the best available data. The results of risk analysis may be used in several ways:

- As a basis for acceptance of a complete system;
- As a basis for improving the system;
- As a means for identifying critical areas for monitoring and surveys;
- As the basis for contingency planning to mitigate the consequences of failure.

The essential consideration for floating platforms in a damaged or operationally induced accident condition is for the unit to remain afloat with limited change in inclination and draft for a specified time to allow the crew to investigate the condition and, if necessary, undertake evacuation. During this time, the main load-carrying structure and a safe area should remain intact; all necessary safety-related control systems should be operable from the safe area. There is a need for stability criteria which address dynamic forces, and the authors suggest that such dynamic analysis would involve less effort than that currently required to assess the structural design. Mooring system failure, with its inherent risk to the marine riser, and the potential for progressive failure after the loss of one line, should receive greater consideration, although surveys, maintenance, and replacement of lines during operation should serve to limit this possibility. The effects of unintentional changes in the unit's attitude on mooring forces should also be considered.

The dominant hazards to offshore structures are related to the marine environment, the latent energy in hydrocarbons and (as in other industries) the potential for human errors which pose a particular threat in view of the rapid technological developments currently taking place. Recent disasters with mobile platforms must not lead to a fatalistic attitude; offshore accidents are a product of man's activities and the safety level is dependent upon how well these activities are conducted and controlled. It is possible to achieve a future safety level which the industry, as well as the public, can accept as satisfactory, but only by devoted safety management by all parties involved. This safety management consists of assessing the total risk and planning the most efficient actions to reduce risks.

OCEAN RANGER FAMILIES FOUNDATION

Submitted November 5, 1984

The Families Foundation submitted observations and recommendations concerning safety, self-regulation, the role of government, worker participation in safety, evacuation systems, search and rescue, the rescue/standby function, and family orientation programs.

The board members of the Foundation have profound doubts about the capacity of the oil industry to regulate its own operations. For this reason it is particularly important to develop and strengthen the role of government in the oil industry. It is necessary for government to provide rules, regulations, and standards which will ensure the protection and welfare of the workers, the environment, and society. More specifically, government must set out clear regulations and certifying procedures pertaining to the design and operation of all plant, equipment, and other operations. In order to ensure that such regulations are adhered to government must also provide a fail-safe method for surveillance and inspection.

The Foundation made several recommendations regarding inspections and monitoring systems. Although there now exists close liaison and co-operation between Canadian Coast Guard, Canada Oil and Gas Lands Administration, and Newfoundland & Labrador Petroleum Directorate inspectors, some integrated system would be preferable. The group also hopes that the Commission will address the question of training and recruitment of inspectors, and that some method of surprise inspection visits will be developed. They also suggested that some method be found to document and investigate examples of unsafe practices in a confidential manner.

In recommending worker participation, the Families Foundation recognized management's reluctance to deal with unions, but suggested as an alternative a designated safety representative from a particular occupational sector of a rig who is chosen by the workers themselves.

To expedite the rate of technological advancements in evacuation systems, a major research and development project should be set up immediately with federal government funding and leadership. Suggested improvements for offshore rescue response capability include:

1. The vessel assigned by Coast Guard to patrol the drilling areas offshore be equipped with a helicopter and appropriate back-up crew and services;
2. An appropriate number of fixed-wing aircraft be stationed at St. John's;
3. Search and rescue personnel monitor the ongoing training and exercise program of the rescue helicopter currently dedicated by the industry.

The Foundation stated that rescue is a specialized task and that on-site rescue requirements cannot be met by existing supply vessels and crews alone. It recommended that at least one specially designed and dedicated rescue ship be contracted by the operators, and that this ship be provided with a helicopter, a trained crew, and proper hospital facilities.

The Foundation strongly endorsed family orientation and educational programs for all new workers and their families.

PETRO-CANADA RESOURCES

Submitted October 12, 1984
S. Wayne Speller

Petro-Canada feels it is important to recognize that research and development are being undertaken by the petroleum industry and government without the benefit of a planning process. An operational environmental data management system is needed to ensure that such research fulfills the future needs of offshore hydrocarbon developers and other offshore resource users. The need to plan for and develop an environmental data management system for offshore regions is manifested in a number of persistent problems associated with ongoing hydrocarbon exploration activities. These include problems with policy and financing of data management which have made it difficult for some government agencies to make data available, real-time data communication problems, and a lack of clear decisions on responsibility, integration, and support for offshore environmental data management systems to address future needs.

In order to solve these problems, a series of planning steps must be taken to understand current user needs and services, to define future user needs, and to develop an environmental data management system that will serve all users. The steps recommended are:

1. Determine the status of current offshore environmental programs;
2. Define the objectives for future environmental programs keeping in mind policy constraints, support capability, and time constraints;
3. Establish an environmental data management system involving decision making on the framework and responsibilities, manpower and financial support, co-ordination of data communication networks, processing and distribution, and scheduling for the organization.

PETROLEUM INDUSTRY TRAINING SERVICE

Submitted March 27, 1984

In 1949 the Canadian petroleum industry and the government of Alberta were deeply concerned about the need to make the drilling industry less hazardous. The result was a series of training programs related to safety, offered by the Department of Extension of the University of Alberta. As the industry expanded, the individual companies were able to change their own training programs as needed, but the University was not able to respond as quickly. Consequently in 1961, the Petroleum Industry Training Service (PITS) was removed from the University and incorporated under the Companies Act as a non-profit training society. An eleven-member Board of Directors provides broad policy guidelines within which PITS works to meet the training needs of the petroleum industry.

With the increase in exploratory work outside of the western sedimentary basin, the petroleum industry encouraged PITS to become more national in its activities. In 1980 the Board of Directors of PITS moved to expand its role, and decided PITS would:

- Become more pro-active and less reactive with regard to training;
- Provide counsel and advice to the industry, and to individual companies, on matters related to training and to manpower planning and development;
- Serve as the interface between government and the industry on matters related to training;
- Become the training and manpower planning arm of the industry in Canada.

The industry decided to co-ordinate its activities on the East Coast by having the Eastcoast Petroleum Operators Association become the Offshore Operators Division of the Canadian Petroleum Association (CPA). CPA in turn provided financial support to PITS and agreed to share facilities with PITS on the East Coast. By June of 1983, the Halifax office was established and arrangements were made to share an office that the industry had already established in St. John's. As soon as PITS had a manager for its East Coast Division, it began to work with the industry to form a Management Board to provide PITS with guidance and advice related to training needs for the offshore. This Board was made up of the senior operating managers on the East Coast from those companies with committed drilling programs in the area.

The training programs offered are the result of continual consultation with the industry and with those governmental departments and agencies directly involved. PITS then searches out a suitable delivery agent who designs the program curriculum and conducts the training. PITS attends to the administrative details, and collects the course fees. Committees of industry and government representatives determine the minimum acceptable training standards in such areas as blowout prevention and well control, operation of fast rescue craft, ballast control, firefighting, and rescue. PITS then ensures that these standards are met.

GLEN R. YUNGBLUT

Submitted May 18, 1984

Glen R. Yungblut
EPI Resources Limited

The author emphasized the importance of avoiding conventional labels in designating the person in charge of a MODU, since labels convey a number of images and impressions of knowledge, experience, and competence but they do not identify in any useful way the qualifications an individual must have to ensure the safe, efficient operation of a MODU. He suggested, instead, identifying the knowledge and experience required. Accordingly, the person in charge must:

1. Have extensive management and organizational experience and skills with the maturity to use them effectively;
2. Know and understand the functioning of the MODU and its critical systems;
3. Know the location, nature, and importance of hazardous zones on the unit;
4. Know the principles of drilling and well control;
5. Know helicopter flight procedures, limitations, capabilities, and the special fire protection systems;
6. Understand the mooring system and the effect of anchor line tensions on the stability of the unit;
7. Know the operation of the resupply system and the limitations and hazards of supply vessels close to the unit;
8. Understand weather, sea conditions, and forecasts;
9. Know how to handle heavy equipment on a moving platform.

As a minimum requirement an individual should have at least four years' experience on a semisubmersible, two of which should be in a senior supervisory position as a deputy to the person in charge. The legal responsibility of the position should be established by regulation which sets out the power and authority of the person in charge. At the same time, a title should be established that avoids the pitfalls of using any of the current labels; platform manager or unit manager were suggested.

ITEM A-9

PROCEDURE RULES FOR PART II HEARINGS

SHORT TITLE

1. These Rules may be cited as the *Ocean Ranger* Marine Disaster Public Hearing Rules.

APPLICATION

2. These Rules apply to that portion of the inquiry of the Royal Commission on the *Ocean Ranger* Marine Disaster contained in the paragraph 2 of the Order-in-Council PC 1982-819 and paragraph 2 of the Lieutenant Governor-in-Council's Commission dated the 16th day of March A.D. 1982.

INTERPRETATION

3. In these Rules:

"Act" means the **Inquiries Act,** R.S.C. 1970, c. 1-13.

"Chairman" means the person appointed by the Governor-in-Council and the Lieutenant Governor-in-Council to be Chairman of the Commission.

"Commission Counsel" means Counsel appointed by the Commissioners and the Lieutenant Governor-in-Council to assist them in their inquiry.

"Commissioner" means a person appointed by the Governor-in-Council and the Lieutenant Governor-in-Council to conduct the inquiry.

"Commission" means the Royal Commission on the *Ocean Ranger* Marine Disaster established pursuant to Order-in-Council PC 1982-819 and the Lieutenant Governor-in-Council's Commission dated the 16th day of March A.D. 1982.

"Governor-in-Council" means the Governor-in-Council of Canada.

"Inquiry" means that portion of the inquiry of the Commission contained in paragraph 2 of Order-in-Council PC 1982-819 and paragraph 2 of the Lieutenant Governor-in-Council's Commission dated the 16th day of March A.D. 1982.

"Order-in-Council" means the Order of the Governor-in-Council No. PC 1982-819 dated the 17th day of March A.D. 1982.

"Lieutenant Governor-in-Council" means the Lieutenant Governor-in-Council for the province of Newfoundland.

NOTICE OF PUBLIC HEARINGS

4. (1) Notice of the public hearings shall be given by publication of the same in the Canada Gazette and the gazettes of each of the provinces of Canada and in such Canadian and foreign newspapers or other publications as in the opinion of the Commission would be appropriate.

(2) A Notice of Public Hearings shall set out the times and places appointed for public hearings.

PURPOSE OF PUBLIC HEARINGS

5. The purpose of the public hearings is to obtain the views of the public on the Commission's mandate contained in paragraphs numbered 2 which direct the Commission to:

> "Inquire into, report upon and make recommendations with respect to:
> (a) both the marine and drilling aspects of practices and procedures in respect of offshore drilling operations on the Continental Shelf off Newfoundland and Labrador. . . . .
> (b) to the extent necessary and relevant, such practices and procedures in other Eastern Canada offshore drilling operations."

The Commission is particularly interested in receiving the views of the public on means of improving the safety of offshore drilling operations.

APPEARANCES BEFORE COMMISSION

6. (1) Any member of the public or representative of any agency, group or association or corporation or any representative of the federal or provincial or municipal government who wishes to appear before the Commission to make a submission relevant to the purpose of the inquiry shall file at the Commission's office on or before the date specified in the Notice of Public Hearings as being the last day for filing Notice of Intention to Appear which shall contain the following:

(a) his or her name, address and telephone number;
(b) the subject matter to be addressed by such person;
(c) a brief summary of the submission to be made if it is to be an oral submission;

(d) a copy of the submission if it is to be a written submission;
(e) the names, addresses and occupations of any persons who may be called in support of any submission;
(f) any qualifications which the person or persons intending to appear may have which would specially qualify them to make representations on the subject matter to be addressed;
(g) a copy of any exhibit intended to be introduced;
(h) the location of the Commission's public hearing at which the appearance will be made;
(i) estimate of the time required to make the submission;
(j) his or her signature.

(2) Any person wishing to appear before the Commission but who is uncertain of the procedure to be followed or of the relevance of the representation proposed to be made should inquire at the office of the Commission where Commission staff will discuss the proposed submission and if necessary, will assist in the preparation of the Notice of Intention to Appear.

(3) Except with special leave of the Chairman, and only then on showing good cause, only those who have filed Notice of Intention to Appear will be permitted to appear and make a submission to the Commission.

INQUIRY PROCEDURE

7. (1) Prior to the commencement of public hearings the Commission shall meet and set a schedule of appearances for those persons who have given Notice of Intention to Appear.

(2) A copy of the schedule of appearances will be mailed to all persons affected by it.

(3) As the hearings are intended to be as informal as is practically possible, persons making submissions will not be sworn, nor will they be subject to questioning except by the Commissioners.

(4) Where written submissions are prefiled the person appearing to present it at the public hearings should not read it but should be prepared to speak to it and discuss it with the Commissioners.

(5) Similarly where persons are making oral submissions to the Commission they should be prepared to discuss the various points in the submission as they are raised.

(6) Submissions may be made by persons individually or in panels.

(7) If any special devices are required by a person making a submission such as slide projectors, cameras, screens, tape recorders, magnetic boards, etc., the person requiring the same should give adequate notice to the Commission staff and if practical the required device will be provided.

LIMITATIONS ON SUBMISSIONS

8. (1) While it is intended that the public hearings proceed in an informal manner submissions must be relevant to the purpose of the hearings.

(2) The Chairman of the Commission may limit, restrict or direct that a submission be discontinued if, in his sole discretion, he determines that the submission or any portion of it is not relevant to the purpose of the hearings.

CHAIRMAN

9. The proceedings of the public hearings shall be at the exclusive direction of the Chairman who shall set any procedure not provided for in these Rules and who shall have the right, if he deems it desirable for the purpose of conducting more meaningful hearings, to relax or waive these Rules.

IN CAMERA HEARINGS

10. (1) The Commission may, in its discretion, hold hearings in camera.

(2) Any person who wishes to make an in camera submission to the Commission should make application to the Secretary of the Commission at the same time as filing Notice of Intention to Appear.

ITEM A-10

NOTICE OF PART II HEARINGS

Royal Commission on the *Ocean Ranger* Marine Disaster
Canada

Commission Royale sur le Désastre Marin de l'*Ocean Ranger*
Newfoundland/Terre-Neuve

NOTICE

The Royal Commission on the Ocean Ranger Marine Disaster has been directed to:

"Inquire into, report upon and make recommendations with respect to:

(a) both the marine and drilling aspects of practices and procedures in respect of offshore drilling operations on the Continental Shelf off Newfoundland and Labrador. . . .

(b) to the extent necessary and relevant, such practices and procedures in other Eastern Canada offshore drilling operations."

In accordance with these Terms of Reference, the Royal Commission set as its goal: to identify practical means of improving the safety of those operations. To this end, it has carried out studies, called for and received written submissions and convened an international conference of experts. It now wishes to complete the process of public consultation before preparing its final report for submission to government.

The views of the public on matters relevant to the Commission's mandate are invited and, if warranted by the response received, Public Hearings of the Commission will be held at the undermentioned places and times.

Persons intending to make a submission must file a Notice of Intention to Appear on or before October 22, 1984, with

David M. Grenville
Commission Secretary
Royal Commission on the Ocean Ranger Marine Disaster
P.O. Box 2400
St. John's, Newfoundland
A1C 6G3

from whom copies of the procedure for the public hearings and information with respect to the form and scope of submissions can be obtained.

Hearings will be as informal as is practically possible. Persons making submissions will not be required to be sworn nor will they be subject to questioning except by the Commissioners.

The Commission may, in its discretion, hold hearings in camera. Any person who wishes to meet the Commission in private should apply to the Commission Secretary.

Time and Place of Hearings

Halifax
Student Union Building
Dalhousie University
Halifax, Nova Scotia
October 30-31, 1984,
commencing 9:30 A.M.

St. John's
Canon Stirling Auditorium
Church of St. Mary the Virgin
Craigmillar Avenue
St. John's, Newfoundland
November 5-6, 1984,
commencing 9:30 A.M.

ITEM A-11

FACT-FINDING VISITS BY COMMISSIONERS

ENGLAND

LONDON
- Tour: Facilities of Burness, Corlett and Partners (I.O.M.) Ltd.
- Meeting: Commission's Chief Technical Advisor, Dr. E.C.B. Corlett and his senior staff.
- Meeting: Representatives from Lloyd's Register of Shipping, Offshore Services Division.
- Joint meeting: Representatives of the Marine Division, Department of Trade, and the Chief of Coastguard for the United Kingdom.
- International Conference on Marine Survival Craft: Life Rafts, Lifeboats, Survival Systems.
- Meeting: Members of the Department of Energy of the United Kingdom on their system of safety regulations.
- Conference on Safety and Pollution Safeguards in the Development of North West European Offshore Mineral Resources sponsored by the Department of Energy of the United Kingdom.
- Seminar by the Safety Department of the British Petroleum Company on British Safety Regulations.
- Meeting: R.D. Pike (Sea Surveys) Limited on evacuation systems and design.

POOLE, DORSET
- Tour: Royal National Lifeboat Institution (RNLI). Viewed rescue craft.
- Meeting: To discuss organization and operation of RNLI.

MORDEN, SURREY
- Tour: KINS Marine and Offshore Services, KINS Applied Technology.

EPSOM, SURREY
- Meeting: Officials of KINS Marine Head Office – The W.S. Atkins Group.

REDHILL, SURREY
- Tour: Bristow Helicopters Ltd.
- Meeting: To discuss industry helicopters' involvement in offshore search and rescue.

EMSWORTH AND GOSPORT, HAMPSHIRE
- Tour: Watercraft (Rescue Boat Division) in Emsworth and Watercraft (Survival Craft Division) in Gosport.

SCOTLAND

ABERDEEN
- Tour: Robert Gordon's Institute of Technology, Offshore Survival Centre. Viewed various survival training demonstrations; met with officials; inspected dedicated standby vessels (converted fishing trawlers).
- Tour: Training Quay at Aberdeen Harbour.
- Attended Offshore North Sea-83 Exhibition.

STONEHAVEN
- Tour: Robert Gordon's Institute of Technology, Offshore Survival Centre, Maritime Rescue Section. Reviewed the training program and rescue craft.

MONTROSE
- Tour: Offshore Petroleum Industry Training Board's Survival Centre.

EDINBURGH
- Tour: Search and Rescue Centre at Pitreavie.
- Meeting: Briefing on United Kingdom's Search and Rescue organization and operations.

SHETLAND ISLANDS
- Tour: Sullom Voe Oil Terminal.
- Meeting: Briefing on Shetland's role in North Sea offshore safety.

PETERHEAD
- Tour: Peterhead Supply Base. Inspected multipurpose supply/standby/firefighting vessel.

FINLAND

HELSINKI
- Tour: Wärtsilä's Arctic Research Institute facilities.
- Tour: Wärtsilä's Shipyard. Viewed vessels under construction.

PORI
- Tour: Rauma-Repola Rig and Shipyard.
- Meeting: To discuss questions regarding rig design and construction.

NORWAY

OSLO
- Tour: Det norske Veritas office and laboratories. Met with senior officials.
- Meeting: Members of the Norwegian Petroleum Consultants A.S., Norwegian Maritime Directorate, and Norwegian Petroleum Directorate to discuss Norwegian system of offshore safety regulation.
- Interviewed two former masters of the *Ocean Ranger*.
- Meeting: Officials of the Norwegian Work Research Institute regarding research related to the offshore work environment.

TRONDHEIM

- Tour: University of Technology, Trondheim.
- Tour: Maritime School of Trondheim. Viewed the ship navigation simulator and the free-fall lifeboat training area. Commissioners Furst and Pardy participated in a free-fall test.
- Tour: Norwegian Hydrodynamic Laboratories. Met with officials concerning their testing facilities.
- Tour: Norwegian Hydrodynamic Laboratories Model Test Basin. Viewed model testing of the *Ocean Ranger*.
- Interviewed a technician who had worked on the *Ocean Ranger* during its construction and early operations.

BERGEN

- Tour: Oil rig *Dyvi Delta*, a design based on the *Ocean Ranger* concept, which was drilling 100 kilometres offshore.
- Interviewed three technical and marine personnel who had worked on the *Ocean Ranger* during its construction and early operations.

STAVANGER

- Tour: Rosenberg Verft Shipyard which is also involved in rig construction.
- Meeting: Chairman and Technical Expert of the *Alexander L. Kielland* Commission, District Judge Thor Naesheim and Professor Torgeir Moan.
- Tour: Oil rig *Dyvi Delta* in Leirvik, Stord, which was undergoing repairs, in addition to having stability sponsons installed.
- Viewed turning of the *Alexander L. Kielland* and toured salvage site.
- Tour: Helikopter Service A.S.
- Meeting: To discuss industry helicopters' involvement in offshore search and rescue.
- Tour: Rogaland Research Institute and *Ullrig*, a land-based drill rig used exclusively for research and technology development.
- Tour: The new Rescue Co-ordination Centre for Southern Norway.
- Meeting: To discuss their search and rescue system.
- Tour: Statoil's and Elf Aquitaine's Search and Rescue Emergency Centres. Met with representatives from these organizations.
- Meeting: Norwegian Contractors to view dry dock facility and outfitting site of concrete platforms under construction.
- Tour: *Gullfaks A* platform under construction.

HAUGESUND

- Tour: Norwegian Maritime Academy of Damage Control and Sea Rescue. Viewed demonstrations.

SWEDEN

GÖTEBORG

- Tour: Götaverken Arendal (GVA) Shipyard for demonstration of GVA/von Tell Nico Lifescape Evacuation System.
- Meeting: Management of Götaverken Arendal AB and von Tell Nicoverken AB to discuss safety aspects of rig design. Viewed rigs and modules under construction.
- Tour: Safety Training School at Lindholmen Yard and Hydraulic Laboratory in Göteborg.

MALMO

- Tour: World Maritime University, Malmo.
- Meeting: To discuss international standards for maritime training.

FRANCE

PARIS

- Meeting: Representatives of Institut Français du Pétrole and Centre de Oceanologique de Bretagne to obtain and review information on research related to offshore safety.

DENMARK

COPENHAGEN

- Meeting: Officials from the Ministry for Greenland, and the Danish Department of Energy, Government of Denmark.

LUXEMBOURG

- International Symposium on Safety and Health in the Oil and Gas Extractive Industries.

UNITED STATES

WASHINGTON, D.C.

- Meeting: Representatives of the U.S. Coast Guard, U.S. State Department, Searle Consortium Limited, and U.S. Navy regarding the acquisition of a radio-isotope based sounding instrument (to be used to measure water levels in ballast tanks of the *Ocean Ranger*) from the U.S. Navy.
- Attended sessions of U.S. Coast Guard inquiry into the *Ocean Ranger* disaster.

BOSTON, MASSACHUSETTS

- Attended sessions of U.S. Coast Guard inquiry into the *Ocean Ranger* disaster.

HOUSTON, TEXAS

- Offshore Technology Conference-83.

CANADA

OTTAWA, ONTARIO

- Tour: National Research Council of Canada facilities. Met with officials concerning their model testing program.
- Tour: Aviation Safety Engineering Facility, Transport Canada, regarding the investigation and testing of physical evidence salvaged from the *Ocean Ranger*.

HALIFAX, NOVA SCOTIA

- Tour: Search and Rescue Region Rescue Co-ordination Centre, Halifax.
- Tour: Nova Scotia Nautical Institute.

CALGARY, ALBERTA

- Seminar on Safety Management for Offshore Operations on the Canadian East Coast.

RIG/VESSEL VISITS:

Diving Support Vessel *Balder Baffin*
St. John's, Newfoundland

Semisubmersible *Bow Drill III*
Grand Banks, Newfoundland

Semisubmersible *Dyvi Delta*
Bergen, Norway

Semisubmersible *Dyvi Delta*
Leirvik, Stord, Norway

Semisubmersible *John Shaw*
Grand Banks, Newfoundland

Research Vessel *Polar Duke*
St. John's, Newfoundland

Drill Ship *Petrel*
Argentia, Newfoundland

Jack-up *Rowan Gorilla*
Scotian Shelf, Nova Scotia

Semisubmersible *SEDCO 706*
Grand Banks, Newfoundland

Semisubmersible *SEDCO 710*
Grand Banks, Newfoundland

Jack-up *Zapata Scotian*
Scotian Shelf, Nova Scotia

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INTERVIEWS WITH OFFSHORE WORKERS

INTRODUCTION

To ensure that the Royal Commission received the views of offshore workers on occupational safety, arrangements were made to visit a number of rigs working offshore Newfoundland and Nova Scotia, to hold meetings with workers, to witness safety drills, and to attend regularly scheduled safety meetings. In order to stimulate discussion and to receive individual opinions, a questionnaire examining safety-related issues was left on board each rig visited. In November, 1984, a group of workers from a cross section of industrial and marine occupations, drawn from six rigs and representing their co-workers, attended a private meeting in St. John's with the Royal Commission. In advance of that meeting workers met with the representatives they had selected to discuss and convey their opinions on the issues identified in the questionnaire. With the reassurance of absolute confidentiality, the discussion that took place was frank and provided insight into the problems encountered by workers off eastern Canada, as well as views on how occupational safety might be enhanced in offshore drilling operations. The following statements are considered accurate representations of comments made by workers.

AREAS OF CONCERN

Relative Risk

Workers generally perceive that the level of safety offshore is lower than for comparable onshore endeavours but that training and safety awareness are at a higher level offshore. They also feel that the relative risk increases during the winter because environmental conditions are more severe.

Safety Meetings

To stimulate greater participation, weekly safety meetings are usually informal and, while attendance is supposedly mandatory, work schedules may prevent some from attending. Safety concerns or problems identified during these meetings tend to be rectified quickly, but if the concern centres on equipment malfunctions, repairs may be delayed due to the unavailability of spare parts. Should management not deal with particular concerns to the workers' satisfaction, there is little recourse available to them. Workers tend not to push safety concerns too hard with management, fearing reprisals, and particularly dismissal. In general, workers do not refuse to work when, in their opinion, unsafe conditions exist. Some workers also felt that a "Safety Man" was not essential and that rig medics could fill this role if they received appropriate training on the rig's industrial and marine operating procedures.

Accident Reporting Procedures

An accident is sometimes not reported in order to maintain a rig's "accident-free" record. Management provides an incentive program for "accident-free" records, but workers feel that this practice does not contribute to improving the overall level of safety on board a rig. Workers, however, did not want to see the incentive program eliminated because the rewards were seen as a part of their total benefits package. Workers also stated that "regulatory over-reaction" to accident reports is another factor that deters conscientious accident reporting procedures offshore.

Workers felt that supervisory personnel tend to intimidate rig medics who are not registered nurses (RNs) into expediting treatment procedures for workers who have received minor injuries. This is done in order to maintain the rig's safety record and to reduce any disruption of the drilling operations. Consequently the workers felt that RNs were better qualified to be rig medics because of their professional status in the medical field.

Incidence of Accidents

Familiarity and experience with a rig's operating procedures and equipment have an effect on accident rates offshore. For this reason and because it is not always fully outfitted, a newly-commissioned rig will tend to have an above-average accident rate. The lack of proper equipment and the length of a tour of duty were identified as areas of concern which could have an impact on accident rates. Workers preferred the two-weeks-on, two-weeks-off schedule. Under the current three-week rotation it is felt that accidents occur more frequently during the third week of duty. The institution of a four-week schedule on one of the rigs operating off eastern Canada was noted with apprehension. It was also noted that workers fully supported the dismissal of those who are accident-prone, if additional training and experience do not improve their job performance.

Onshore Management Input

The workers felt that decisions made on shore about a rig and its operations offshore often affect safety adversely and that insufficient recognition is given to the conditions offshore and to the opinions of those on-site.

Training

All workers felt that basic survival training should be mandatory for all personnel, that refresher courses should be required every one to three years, and that workers should be paid while they are taking these courses. They felt that the operators and drilling contractors should develop consistent policies on basic survival training programs and that such training should be delivered by the private sector. It was generally felt that specialist training is more effective for teams that specialize in well control and firefighting.

Industrial and marine training should be combined with on-the-job training before individuals are certified. The practice of the industry, however, of conducting training during workers' off-hours is tiring to the participant and reduces his ability to perform regular duties safely. It was also stated that the qualifications for ballast control operators were not receiving adequate attention.

Training Drills

Drills and exercises to complement training are held regularly under fairly realistic conditions, although their repetitiveness makes them boring to workers. Their importance, however, is generally realized. The only joint exercises undertaken regularly are man-overboard drills which involve only the rig and its standby vessel.

Rig Inspections

Inspectors from the regulatory authority are not considered to have much effect on overall safety because of their lack of practical knowledge and because they deal primarily with senior rig management. The workers thought that inspectors with increased industrial knowledge could improve safety on board.

Job Quality

Morale problems do exist with offshore workers as a result of a combination of bad weather, hard work, personal problems, and boredom. Not all jobs require intense concentration for an extended period nor are they physically demanding, thus job sharing is an attractive solution to some of these problems. Some companies have made confidential counselling available to offshore workers by telephone and this service is viewed positively by the workers. Family orientation programs to offshore work, as conducted by some companies operating in the North Sea, are not universally welcomed by workers off eastern Canada.

Labour Unions

It was noted that Norwegian-owned rigs are unionized and that a greater emphasis appears to be placed on marine safety. While some of the workers acknowledged that unions can contribute to safety, there was a general feeling that they would not be effective offshore eastern Canada and that work efficiency would suffer greatly if unions were introduced.

Search and Rescue

The workers felt that search and rescue should be the responsibility of industry. They also felt that too much effort is being placed on improving rig designs without stressing the need for improvement in the launching systems of lifeboats and in the lifeboats themselves.

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PART II STUDIES AND SEMINARS

[The studies are presented in the same sequence as published in Volume 3 Summary of Studies & Seminars. *Asterisks indicate studies that were not summarized for Volume 3.]*

INTRODUCTION

The Risks of Offshore Oil and Gas Exploratory Drilling in Eastern Canadian Waters
Ian Burton, Director
Institute for Environmental Studies
University of Toronto
Toronto, Ontario
May 1984

ENVIRONMENT

A Review of Ice Information for Offshore Eastern Canada
NORDCO Limited
St. John's, Newfoundland
August 1984

An Evaluation of Ice Management Systems in Support of Eastern Canada Offshore Exploratory Drilling Operations
Manadrill Drilling Management Inc.
Calgary, Alberta
August 1984

A Review of the State-of-the-Art in Marine Climatology on the East Coast of Canada
V.R. Swail and L.D. Mortsch
Canadian Climate Centre
Atmospheric Environment Service
Environment Canada
Downsview, Ontario
April 1984

Weather Forecasting Services for the Canadian Offshore
Part 1: Organization of Responsible Agencies and Current Practice
Part 2: Assessment of Adequacy
Seaconsult Limited
St. John's, Newfoundland
August 1984

An Assessment of the State of Knowledge of East Coast Offshore Wave Climatology
J.R. Wilson, Marine Environmental Data Service
W.F. Baird, W.F. Baird & Associates
Ottawa, Ontario
June 1984

Oceanographic Information for the Eastern Canadian Offshore: Adequacy for Exploratory Drilling
Seaconsult Limited
St. John's, Newfoundland
August 1984

The Adequacy of Available Seabed Information as Input to Design Criteria and Operating Constraints for Eastern Canada Offshore Exploratory Drilling
Jacques, Whitford & Associates Limited
Halifax, Nova Scotia
January 1984

*Environmental Risks from Offshore Exploration**
Fisheries & Oceans Canada
St. John's, Newfoundland
Environment Canada
Halifax, Nova Scotia
January 1984

DESIGN

An Essay on the Design of Mobile Offshore Drilling Units.
Report on Mobile Offshore Drilling Unit Design Evolution
Earl & Wright Consulting Engineers
San Francisco, California, USA
May/June 1984

Information Flow Report;
Jack-ups with Reference to the East Coast of Canada
Noble, Denton & Associates, Inc.
Houston, Texas, USA
November/December 1984

*To Appraise Critically the Design, Operation, and Performance Monitoring of Systems Critical to the Safe Operation of MODUs**
Det norske Veritas (Canada) Limited
Calgary, Alberta
June 1984

*Stability, Model Testing, Ballasting and Instrumentation**
Burness, Corlett & Partners (IOM) Limited
Ramsey, Isle of Man
August 1984

SAFETY MANAGEMENT

An Evaluation of Industry Safety Management in Eastern Canada Offshore Drilling Operations
Manadrill Drilling Management Inc.
Calgary, Alberta
June 1984

Assessment of the Normal and Emergency Command Structures Relating to Drilling Systems for Eastern Canada Offshore Drilling Operations
Currie, Coopers & Lybrand
Calgary, Alberta and Halifax, Nova Scotia
July 1984

Assessment of the Means of Communications in Relation to Eastern Canada Offshore Exploratory Drilling
NORDCO Limited
St. John's, Newfoundland
July 1984

TRAINING

Marine and Safety Training in the Eastern Canadian Offshore Petroleum Industry
College of Fisheries, Navigation, Marine Engineering & Electronics
St. John's, Newfoundland
May 1984

HEALTH

Occupational Health Study
Centre for Offshore & Remote Medicine (MEDICOR)
Faculty of Medicine
Memorial University of Newfoundland
St. John's, Newfoundland
February 1984

ESCAPE AND SURVIVAL

Assessment of the Means for Escape and Survival in Offshore Exploration Drilling Operations
Hollobone, Hibbert & Associates Limited
London, England
June 1984

RESCUE

An Assessment of Search and Rescue for East Coast Offshore Exploration Drilling Operations
Vice-Admiral J.A. Fulton (Ret'd)
Lt. Colonel J.E. Dardier (Ret'd)
Major H.F. Pullen (Ret'd)
Halifax, Nova Scotia
November 1984

REGULATIONS

Safety in the Design, Construction, and Operation of Offshore Oil and Gas Installations: A Comparative Analysis of the Regulatory Structures of Norway, Canada, United States and the United Kingdom
Dalhousie Ocean Studies Programme
Dalhousie University
Halifax, Nova Scotia
September 1984

An Evaluation of the Management of the Regulatory Process in Eastern Canada Offshore Drilling.
Task and Skill Analysis of Agencies Regulating East Canada Offshore Drilling
National Petroleum & Marine Consultants Limited
St. John's, Newfoundland
June 1984

*A Guide to Canadian Regulations Pertaining to Safety on East Coast Drilling Units**
Ian Townsend Gault
Dalhousie University
Halifax, Nova Scotia
Christian Yoder
University of Calgary
Calgary, Alberta
May 1984

SEMINARS:

Model Testing
December 14, 1983

Risk Analysis
May 2, 1984

Occupational Health
June 26-27, 1984

The Environment
June 27-28, 1984

Safety Management
September 17, 1984

Offshore Training
September 24, 1984

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APPENDIX B

REPORT ONE RECOMMENDATIONS

ITEM B-1

PART I RECOMMENDATIONS AND THEIR IMPLEMENTATION STATUS

Energy, Mines and Resources
April, 1985

[Editor's note: The "Summary of Action Taken by the Government of Canada in Relation to the Recommendations of the Royal Commission on the Ocean Ranger Marine Disaster" was prepared by Energy, Mines and Resources Canada. The report, reproduced here, was released to the public on April 18, 1985.]

INTRODUCTION

The Royal Commission on the *Ocean Ranger* Marine Disaster was established by the governments of Canada and Newfoundland immediately following the tragic sinking of the semisubmersible drilling rig *Ocean Ranger* off Newfoundland on February 15, 1982.

T. Alexander Hickman, Chief Justice of the Trial Division of the Newfoundland Supreme Court, was appointed Chairman of the Royal Commission and five other distinguished Newfoundlanders were appointed Commissioners. In August 1984, Chief Justice Hickman presented the Commission's Part One Report, *[Report One: The Loss of the Semisubmersible Drill Rig* Ocean Ranger *and its Crew]*, to both governments.

The Royal Commission's Part One mandate was to investigate the loss of the *Ocean Ranger* and to make any recommendations it saw fit arising out of its investigations. Sixty-six recommendations were made, directed at government and industry, dealing with rig design, evacuation, search and rescue, training and regulation.

It is noted that the federal government took action on several fronts immediately following the disaster, using its own preliminary investigations as a basis. In addition, government closely monitored the public hearings of the Royal Commission and immediately took corrective action, where the evidence showed that this would be beneficial. Consequently, by the time the Royal Commission's Part One Report was completed, a number of its recommendations had already been acted upon. Today, approximately 80 percent of the Commission's 66 Part One recommendations have been partially or fully implemented. A very few are considered impractical, mainly on technical grounds, and will not be implemented.

The Royal Commission's recommendations affect a number of federal departments and agencies, particularly Energy, Mines and Resources, Canada Oil and Gas Lands Administration, Transport, Coast Guard, National Defence, Employment and Immigration, Environment, Fisheries and Oceans, Justice, and Labour. The action being taken by the federal government as a result of the Royal Commission's recommendations is monitored by an interdepartmental committee of senior officials which meets regularly to report on progress and discuss problems related to the implementation of the recommendations.

In fulfilling its Part Two mandate, the Royal Commission is focussing upon the broader question of offshore safety. Its mandate in this regard is to inquire into, report upon and make recommendations with respect to marine and drilling practices offshore eastern Canada. The Royal Commission's second, and final, report is expected in the summer of 1985.

From the inquiry's inception, the Commission and the federal government have worked in close co-operation towards the mutual goal of safety offshore. The government has provided to the Commission all information it has requested and in the more technical aspects of the Commission's work there has been a fruitful exchange of ideas.

The meticulous work of the Royal Commission has received acclaim from the international maritime community. The federal government feels that this acclaim is well earned, and regards the Commission's work as the most significant milestone yet achieved in the field of offshore safety.

SUBJECT OF RECOMMENDATIONS:

1. Assessment
2. Structure
3. Systems Analysis
4. Chain Lockers
5. Ballast Systems
6. Tank Sounding
7. Tank Contents
8. Sea Valve Control
9. Draft Reading
10. Anchor Tensions
11. Weight Audit
12. Downflooding/Stability
13. DPA/ADW Validity
14. Design Standards
15. Regulations/Consultation
16. Operational Standards
17. Operational Standards
18. Information Disclosure
19. Information/Security Bond
20. Critical Systems
21. Data Collection
22. Evacuation Systems
23. Lifeboats
24. Liferafts
25. Lifeboat Crews
26. Lifeboat Crews
27. Lifeboat Crews
28. Lifeboat Crews
29. Lifeboat Crews
30. Lifeboatmen/Certificates
31. Training – Standards
32. Training – Certification
33. Certification – International
34. Training – ballast control
35. Training – ballast control
36. Training – ballast control
37. Training – ballast control
38. Training – ballast control
39. Training
40. Offshore Employment Register
41. Local Residents
42. Emergency Response
43. Standby Vessels
44. Standby Vessels
45. Standby Vessels
46. Standby Vessels
47. Standby Vessels
48. Standby Vessels
49. Standby Vessels
50. SAR
51. SAR
52. SAR
53. SAR
54. Contingency Plan
55. Crew Evacuation
56. SAR
57. Weather Reporting/Forecast
58. Weather Forecast
59. Significant Event – definition
60. Significant Event – KG
61. Reporting – Measurements
62. Address/Alarm Systems
63. Ballast Systems – Operations Manual
64. Booklet of Operating Conditions
65. Ballast Systems
66. Ballast Systems – Control

Key to Acronyms:	
BOT	Basic Offshore Training
BOST	Basic Offshore Safety Training
CCG	Canadian Coast Guard
COGLA	Canada Oil and Gas Lands Administration
DND	Department of National Defence
DOE	Environment Canada
CEIC	Employment and Immigration Canada
MED I	Marine Emergency Duties
MED II	Marine Emergency Duties for all vessels
MED III	Marine Emergency Duties for senior personnel on commercial vessels – leadership training
PITS	Petroleum Industry Training Service

1. That all drilling units be subject to an immediate review of structural openings leading to areas containing critical equipment affecting the stability and safety of the rig and that this review include an assessment of potential environmental forces on these openings, and of the strength of the material used to cover them. That, if the strength of the material is deemed not to provide an adequate safety margin, it be reinforced or removed and replaced with material of appropriate strength. [Report One: The Loss of the Semisubmersible Drill Rig *Ocean Ranger* and its Crew, p. 141]

Implementation Status: (CCG)

All drilling units operating on the Grand Banks have been inspected and assessed against the *Interim Standards Respecting Mobile Offshore Drilling Units [Interim Standards]*. Compliance by individual drilling units with these standards is well in hand. Remaining drilling units operating in other offshore Canada Lands have also been inspected and assessed. Compliance by individual drilling units operating on the Grand Banks is expected to be complete before the 1985/86 drilling season.

2. That all drilling units be required to have or to install, over the openings referred to above, covers that can be quickly and easily secured in the event of adverse weather forecasts. That each drilling unit be required to establish and enforce operating procedures that ensure the closing and securing of these covers when weather forecasts or actual conditions exceed established criteria. (p. 142)

Implementation Status: (CCG)

It is agreed that areas containing critical equipment affecting the stability and safety of a drilling unit should have covers that can be secured in the event of adverse weather conditions. The watertight and/or weathertight integrity of the drilling unit, its internal and its external openings are detailed in sections 27 to 32 of the *Interim Standards*. These requirements are taken directly from the International Maritime Organization's (IMO) *Code for the Construction and Equipment of Mobile Offshore Drilling Units* (1980) and reflect the international approach to water-/weather-tight integrity from loadline and stability perspectives. Instructions and operating procedures are contained in MODU operating manuals and it is standard marine practice to "batten down" when adverse weather conditions are forecast.

3. That all equipment critical to the stability and safety of the rig be subject to a systems analysis which includes an analysis of the susceptibility of the equipment to damage and a review of the adequacy of the backup system, if any, and that, where required, appropriate measures be taken to protect that equipment from reasonably foreseeable risks. (p. 142)

Implementation Status: (CCG/COGLA)

In the rig assessment process, mentioned above, systems and equipment critical to the stability and safety of the rigs are inspected and demonstrated to the satisfaction of CCG in accordance with the requirements of the *Interim Standards* (Part 1, section 8(1)). The *Interim Standards* are subject to ongoing review by CCG/COGLA/Industry.

Following the disaster COGLA commissioned a comprehensive study of the ballast systems of all units operating off the East Coast. As a result, measures have been taken to improve the systems – the installation of secondary deballast systems, the provision of a second ballast control station and so forth.

4. That if flooding one or more of the chain lockers adversely affects the stability of the rig, they be equipped with flooding alarms and be adequately weatherproofed and fitted with effective means of dewatering them. (p. 142)

Implementation Status: (CCG)

Dewatering of chain lockers is covered by the *Interim Standards* (Part IV, section 39(1)(b)(ii)). Chain locker drainage and mud build-up in the lockers are being given special attention during assessment and inspections. The provision of alarms, which is under study, may prove to be impractical. The water-/weather-tightness of chain locker openings is examined during the inspections and assessments mentioned above.

5. That the system of pumping ballast water on drilling units be capable of pumping at an adequate flow rate to restore the rig to level attitude when the rig is inclined up to and including the static downflooding angle or the angle reached in the "worst case" damage stability situation, whichever angle is the greater. (p. 142)

Implementation Status: (CCG)

In the application of the *Interim Standards* respecting MODUs, as applied to new units, the "worst case" damage condition has been set at 15 degrees of heel. (Part III section 25(1)(b).) Similarly, the static angle of heel for the "intact condition" attributable to wind action is also limited to 15 degrees of heel (Part III section 24(1)(a)(i)). The drilling unit's bilge and ballast system is required to operate up to 15 degrees angle of heel. (Part III section 25(1)(d))

If the drilling unit's static downflooding angle is less than 15 degrees, then requirements of this Recommendation have been met. Dynamic roll angles with respect to each new drilling unit's particular flooding ingress points, which would be subject to progressive stages of flooding commensurate with successive angles of heel beyond 15 degrees, are governed by criteria prescribed in Part III section 24(1)(c)(ii) of the *Interim Standards*. In the case of existing column-stabilized MODUs, secondary deballasting systems are being retro-fitted in order to achieve an equivalent standard following the inspections and assessments mentioned above.

6. That sensor tubes for tank soundings be located to permit maximum possible accuracy of readings when the rig is in other than a level attitude. (p. 142)

Implementation Status: (CCG)

The above is agreed for normal angles of trim and heel. The location of sensor tubes (sounding pipes) is somewhat constrained by structural arrangements but efforts are made to place them in the best position. In the case of a semisubmersible it is a complex matter to ascertain the correct contents of tanks under all possible inclinations. (*Interim Standards* Part IV, section 41(1),(2))

7. That conversion tables be provided for accurate assessment of tank contents when the rig is in other than a level attitude. (p. 142)

Implementation Status: (CCG)

To provide conversion tables for the accurate assessment of tank contents in a semisubmersible for all angles of inclination would be extremely complicated, as the unit can incline in any direction and thus involve the addition of several sensors. The subject was discussed with industry at the MSAC offshore subcommittee meeting in November 1984. At the next meeting of this subcommittee, in May 1985, CCG and industry will agree on a simplified method to provide a reasonable degree of accuracy in assessing tank contents.

Note: The Marine Safety Advisory Council (MSAC) is a consultative body representative of federal and provincial government agencies, industry, labour and other groups, with a recognized interest in the safety of shipping, navigation and marine pollution matters. This Council, which meets bi-annually in May and November, advises the Canadian Marine Transportation Administration, through the Director General, Ship Safety Branch, on technical matters which fall within the purview of the Ship Safety Branch. At present, MSAC has six technical committees (navigation safety, nautical certification, marine engineer certification, accident prevention and survival, small craft, and cargo). During the November 1985 MSAC meeting, members endorsed the creation of a seventh or Offshore Technical Committee comprising government (COGLA/CCG) and representatives of the offshore industry.

This committee formed a working group which was tasked with refining the *Interim Standards*. All of the relevant Recommendations from the Royal Commission will be considered during this process. The working group met on November 15, 1984, in St. John's, Newfoundland, in order to formulate a work plan. A

second meeting held on January 29, 1985, discussed the proposed changes to the *Interim Standards*. Upon agreement by all concerned, the *Interim Standards* will be amended for final presentation at the next MSAC meeting in May, 1985.

8. That sea chest valves be capable of being shut manually from a position on the rig which is above the weather deck. (p. 142)

Implementation Status: (CCG)

Required by *Interim Standards* and being applied progressively during assessment (Part IV, section 39(1)(b)(v)). Extended spindles, manual hydraulic or manual pneumatic systems satisfy this requirement.

9. That all drilling units be equipped with remote draft sensing and reading devices. (p. 142)

Implementation Status: (CCG)

Required by *Interim Standards* (Part IV, section 42). All units in the present fleet are fitted with the required devices.

10. That all drilling units be equipped with recording gauges that provide accurate determination of maximum and minimum anchor tensions and produce a permanent record of all anchor tensions. (p. 142)

Implementation Status: (CCG/COGLA)

All units operating in Canada Lands are equipped with anchor tension gauges and owners are required to maintain records of the tension on every anchor cable (*Canada Oil and Gas Drilling Regulations [COGLA Drilling Regulations]*) 177(a)(ii)). Some of the rigs in Canada Lands are already equipped with permanent recording devices and the question of making this a mandatory requirement on all rigs will be the subject of discussion at the May, 1985 meeting of the Maritime Safety Advisory Council.

11. That each drilling unit be subject to a quadrennial deadweight check and weight audit carried out under the supervision of the regulatory authority or its authorized agent. (p. 142)

Implementation Status: (CCG)

Required by *Interim Standards* (Part I, section 8(4)(b)). A deadweight check is carried out quadrennially and an audit of operators' weight calculations is done annually. Additionally, weight audits are conducted on a routine basis by the MODU master or ballast control operator.

12. That the use of static downflooding angles for calculation of a righting/heeling energy ratio in the moment balance diagram be discontinued except where the point of downflooding is adequately weather proofed. That in the absence of weatherproofing at the point of downflooding, a dynamic angle be calculated based upon deck flooding in design wave conditions and, where appropriate, on model tests and computer simulations. (p. 142)

Implementation Status: (CCG)

The first statement of this Recommendation is covered by current practice, whereby no allowance is given beyond the point of downflooding.

With reference to the second statement, it is international practice to use static or quasi-static conditions to assess the stability of MODUs based on historical demonstrated performance. The use of models or computer simulation leads to subjectivity in the interpretation of results and, for this reason, has largely been ignored by regulatory bodies.

Wind forces have been accounted for in the stability criteria contained in the *Interim Standards* and the other dynamic forces, including waves, which may significantly affect the stability characteristics of the unit, are considered to be accounted for by the area ratio requirement of the present criteria. Furthermore, the *Interim Standards* are being modified so that the volumes of compartments which are inadequately weatherproofed throughout the range of stability will be excluded in the computation of the cross curves of stability, that is, the "saw tooth" righting moment curve of Figure 1, page 20 of the *Interim Standards*, will be

redrawn as a smooth curve of lesser order, commencing from the upright position.

13. That the continuing validity of a Drilling Program Approval or Authority to Drill a Well be conditional upon the validity of all certificates applicable to the drilling unit as detailed in the April 1984 COGLA Guidelines and Procedures [Drilling for Oil and Gas on Canada Lands – Guidelines and Procedures], *Section 1, Appendix B.* (p. 143)

Implementation Status: (COGLA)

Operators are advised at the time of approval of a Drilling Program or Authority to Drill a Well that the approval is conditional upon the continued validity of all certificates.

14. That Canada adopt standards for the design, construction and stability of offshore drilling units and that no drilling unit be permitted to operate unless it meets those standards as evidenced by a Certificate of Fitness *issued by or on behalf of the regulatory authority.* (p. 144)

Implementation Status: (CCG/COGLA)

Canada now has the Canadian Coast Guard *Interim Standards*. All units operating in Canada Lands are assessed against these standards and are required to comply with them. Appropriate certification equivalent to a *Certificate of Fitness* is issued by CCG. It is intended to adopt the *Interim Standards* as Regulations when the proposed amendment to the *Canada Shipping Act* is enacted by Parliament.

15. That whether regulations or guidelines are used to express the wishes of the regulatory authority, there be consultation with industry to ensure proper administration and consistent enforcement. (p. 145)

Implementation Status: (CCG/COGLA)

There is regular consultation between the regulatory authorities and industry to ensure proper administration and consistent enforcement of regulations, guidelines and standards. A number of groups have been established for this purpose and include the Canada Lands Safety Advisory Council, Marine Safety Advisory Committee, Medical Advisory Group on Offshore Health, Joint Government-Industry Offshore Training Committee, Marine Offshore Training Group of MSAC's Training and Qualifications Committee. The Marine Safety Advisory Committee recently established an offshore committee, composed of representatives of industry and government, to deal exclusively with technical matters related to the offshore industry.

16. That Canada adopt general operational standards for drilling units. (p. 145)

Implementation Status: (CCG/COGLA)

General operational standards for drilling units already exist. The operations manual required by the CCG *Interim Standards* and the Newfoundland Petroleum Directorate outlines various operational requirements. The *COGLA Drilling Regulations* and *Drilling for Oil and Gas on Canada Lands – Guidelines and Procedures (COGLA Guidelines)* also contain requirements related to drilling operations, recording and reporting procedures, monitoring procedures for environmental conditions and so forth, that are applicable to all units.

17. That in addition to the general and type-specific operational standards there also be platform- or rig-specific operating standards or procedures. That these standards be set out in a manual of operating conditions and emergency procedures for each unit and be subject to the approval of the regulatory authority. That the conditions or procedures which are mandatory be clearly designated and provision made for logging and reporting to the regulatory authority any non-compliance with mandatory provisions. (p. 145)

Implementation Status: (CCG/COGLA)

The *COGLA Drilling Regulations* (section 79) require operators to submit rig-specific contingency plans for eight prescribed categories of emergency. The purpose of a contingency plan is to define the responsibilities of the drilling unit's key personnel; to outline the basic procedures for responding to the emergencies; and to provide the unit with a plan of action for every foreseeable emergency situation. Contingency plans are reviewed by COGLA and its resource agencies with which COGLA consults on search and rescue and environmental matters. Observations

received from COGLA personnel and external reviewers of contingency plans are consolidated by COGLA and forwarded to the operator. The *COGLA Guidelines* stipulate that the observations are considered to be amendments to the operator's rig-specific contingency plans.

18. That no drilling unit be permitted to drill unless and until the owner or other appropriate person provides the appropriate Canadian authority with an irrevocable authorization directing the builder, designer, classification society and the state of the rig's registry to provide the information and documentation with respect to the rig as may be requested. (p. 145)

Implementation Status: (COGLA)

Work is under way regarding the legal process necessary for implementation.

The drilling regulations and COGLA's approval process provide for the disclosure of detailed information concerning rigs to be used in proposed drilling programs. The irrevocable authorization would serve as a supplementary means of obtaining further information where required. While the authorization would not bind third parties, it would remove one obstacle to the disclosure of confidential information by such third parties to Canadian government authorities. The operator could be required to tender the rig owner's authorization in support of an application for drilling program approval. Implementation will likely entail amendment to the drilling regulations, particularly if the requirement is to be made applicable to drilling progams which have already been approved.

19. That no drilling unit be permitted to drill unless and until the owner or other appropriate person provides the appropriate Canadian authority with an irrevocable undertaking to comply in all respects with the request, demands and subpoenas of any Canadian authorized marine casualty investigation and that to ensure compliance with that undertaking the owner or other appropriate person be required to post a bond or other security in an amount or type satisfactory to the Canadian authority. (p.145)

Implementation Status: (COGLA)

Consideration has been given to the legal process necessary for implementation. Preliminary consultation with bond underwriters has taken place.

A possible legal difficulty lies in the structuring of conditions which, while definite enough for bonding purposes, meet the words of the recommendation "...to comply in all respects with the requests, demands and subpoenas of any Canadian authorized marine casualty investigation...." A practical difficulty arises out of the fact that the amount of the bond must be high in order for it to be a sufficient negative incentive. The cost of providing such a bond will be correspondingly high. Some rig owners may not be bondable. Those which are will likely attempt to pass the cost on to the operator. The operator in turn may attempt to pass the cost to Government through the PIP program and the income tax system. If the requirement relates only to foreign rigs, their competitiveness in the Canadian market would be reduced. The economic and operational impact on the oil industry of this recommendation remains to be assessed.

The undertaking to comply and the bond could be obtained in the same manner as the irrevocable authorization mentioned in Recommendation 18. Implementation will likely entail amendment to the drilling regulations, particularly if the requirement is to apply to drilling programs which have already been approved.

20. That the appropriate regulatory authority conduct or cause to be conducted an analysis of the critical systems and their interrelationships on all drilling units in order to determine the adequacy of their response to emergency conditions. That there be subsequent periodic analyses as may be warranted. (p. 146)

Implementation Status: (CCG/COGLA)

All critical systems such as the location of fairleads and anchor cables, location of ballast control room, portlights, unprotected openings, throw-overboard life rafts, have been considered subsequent to the disaster and corrective action has been taken where necessary. (See Recommendation 3 concerning equipment and systems critical to stability and safety)

21. That data be collected on equipment failures, accidents, dangerous occurrences, and any "significant events" as defined by the appropriate regulatory authority. That the data collected be systematically analyzed, indexed and disseminated to the offshore industry in a form that does not identify, if possible, the unit on which the event occurred. (p.146)

Implementation Status: (CCG/COGLA)

The collection of data and information relative to Marine/Drilling events is covered by the *Canada Shipping Act* (sections 541 to 580) and *COGLA Drilling Regulations* (section 171). Dissemination of information on reported events and corrective measures is done through Ship Safety Bulletins, Notices to Mariners, Notices to Operators, Investigation Reports, etc., which usually do not identify the unit on which the event occurred.

22. That Canadian authorities consider the development of an evacuation system that will provide an adequate and safe means of escape in foreseeable emergency and storm conditions to be a matter of the utmost priority and that they encourage through every means at their disposal the earliest development and use of a safe system. (p. 147)

Implementation Status: (CCG/COGLA)

COGLA and East Coast drilling unit operators have developed co-operative regional alert plans and have co-ordinated individual emergency plans to ensure the quickest and fullest responses to a variety of emergency situations including severe storm conditions.

CCG has contracted Memorial University of Newfoundland in St. John's to conduct a survey of existing, developing and conceptual MODU evacuation systems. In addition, the ministers of Energy, Mines and Resources and Transport Canada are encouraging the research and testing by government and industry of new evacuation systems which appear to be suitable for service in offshore Canada Lands. The CCG has assumed the role of federal co-ordinator to lead evacuation systems research, to acquire consultant services, to arrange government-industry consultations and to field test selected evacuation system components at the appropriate time.

23. That drilling units be equipped with sufficient lifeboats for 200 percent of the crew. (p. 147)

Implementation Status: (CCG)

Required by *Interim Standards* (Part X, section 94(2)(a)).

24. That life rafts required to be on drilling units be davit-launched. (p.147)

Implementation Status: (CCG)

Required by *Interim Standards* (Part X, section 94(2)(c)).

25. That drilling units be required at all times to have sufficient lifeboat crews to man lifeboats for 100 percent of the crew plus one additional lifeboat crew. (p. 148)

Implementation Status: (CCG)

The *COGLA Drilling Regulations* section 15(d), administered by COGLA, require personnel employed on a drilling program to undergo offshore survival training in the form of MED, BOT or BOST courses.

These courses include training in the use and operation of survival craft used by MODUs operating in offshore Canada Lands. Most trainees have skills and knowledge which meet the intent of this Recommendation.

26. That a lifeboat crew consist of four persons each holding a Certificate of Efficiency *as a lifeboatman under the* Certification of Lifeboatmen Regulations *and that in addition to these requirements each prospective member of a lifeboat crew be required to establish to the satisfaction of the examiner that he is skilled and knowledgeable in:*
a) passenger control and crew organization in emergencies involving evacuation of the unit;
b) survival procedures and techniques;
c) search and rescue procedures and organization;
d) the sea-keeping characteristics of the lifeboats;
e) the operation of the lifeboat radio. (p. 148)

Implementation Status: (CCG)

The additional skills and knowledge listed in this Recommendation are included in the MED curriculum and form part of the syllabus for the examination for a Lifeboatman Certificate Qualified in Marine Emergency Duties. Most workers in the Offshore Industry have received the Coast Guard-approved MED course or one of the two PITS-sponsored Offshore Safety Training courses, BOT and BOST.

It should be noted that the BOT and BOST courses, (See response to Recommendation 25), were designed for MODU emergencies and in some respects are more appropriate than MED for these units. Persons so trained, however, do not work with the full range of vessel equipment prescribed by the MED curriculum and for this reason cannot be certificated as lifeboatmen.

A Marine Emergency Duties Seminar is scheduled for September 1985 in St. John's, Newfoundland. The objective is to rationalize the course content of the various courses presently offered in order to introduce a new CCG approved training course suitable for all sectors of the marine industry.

27. The lifeboat crews be required to be trained in the use and operation of the type of lifeboat to which they are assigned and that this training include actual launching and operation of the lifeboat in the sea. (p. 148)

Implementation Status: (CCG)

An important item in the curriculum of the MED III leadership emergency course is team training which stresses the importance of frequent drilling and instruction of crews in the operation of the lifesaving, firefighting and other emergency equipment on the vessel. Leadership, team training and type familiarity are elements which are common to all seagoing vessels however employed, whether under way or not.

The person in charge of Canadian self-propelled units (MODU) is now required (*Canada Shipping Act*, section 126) for certification to have MED III training and is thus qualified to train lifeboat crews in the operation of their assigned craft. In addition, the *COGLA Drilling Regulations* (section 151), administered by COGLA, prescribe the MODU operator's responsibilities for specified safety drills.

All personnel employed on MODUs are required to undergo offshore survival training in the form of MED, BOT or BOST courses, which include training and instruction in the use and operation of lifeboats. It is the master of the MODU's responsibility to ensure the training specified in this Recommendation is in accordance with the Boat and Fire Drill Regulations and as implied in section 151 of the *COGLA Drilling Regulations*.

Launching of boats and survival craft is conducted when the MODU is in port or sheltered waters. Launching in exposed locations may also be conducted on occasion but any such drill should be done at the master's discretion rather than being legislated.

28. That lifeboat crews be required to launch and operate the lifeboat in the sea at least twice each year. If this cannot be conveniently or safely done from the drilling unit then it should be done from a shore-based installation. (p. 148)

Implementation Status: (CCG)

Currently, lifeboat drills include lowering of lifeboats. The boats are launched into the water when weather permits, and always when the drilling unit is in port. (See response to Recommendation 27)

29. That industry establish appropriate practices and incentives which recognize the importance of the lifeboat crews and which ensure adequate time and resources for their preparation and training. (p. 149)

Implementation Status: (COGLA)

The intent of this industry oriented Recommendation is recognized. Drills are now required after each crew change, which is normally every two weeks. It is felt that incentives should not be subject to legislation. (See response to Recommendation 27)

30. That drilling contractors be required by regulation to identify to inspectors during their periodic inspections of MODUs those crew members who are certificated lifeboatmen. (p. 149)

Implementation Status: (CCG)

CCG inspectors have been instructed to ascertain the number of certificated lifeboatmen during inspections (CCG telex, 28.11.84). Consideration is being given to incorporating this requirement in the *COGLA Drilling Regulations*, which are presently under review.

31. That there be an assessment of the adequacy of training methods used on drilling units, with particular reference to "on-the-job" training methods; that the regulatory authority, in conjunction with representatives of the offshore industry, determine the adequacy of that training and establish minimum standards for specified positions. (p. 149)

Implementation Status: (CCG/COGLA/CEIC)

CCG and COGLA have the legislative responsibility for the adequacy of training, establishment of minimum standards and certification for specific occupations on the MODUs.

Currently, the training levels of all key personnel are reviewed by COGLA prior to the issuance of a drilling program approval. CCG and COGLA, with the assistance of CEIC and in consultation with industry, are currently engaged in the process of establishing minimum standards and certification for specific occupations on the MODUs for both formal and on-the-job aspects of the training.

Government and industry have conducted separate indepth studies over the past year which has resulted in two reports on key positions, and training and certification of crews of drilling units. These reports provide the working papers from which final proposals for regulations will be made to MSAC respecting marine personnel, and to Canada Lands Safety Advisory Council (CLSAC) respecting industrial positions.

The Certification Committee of the Marine Safety Advisory Council established a working group on offshore training at its November 1984 meeting. This group, using the documents mentioned above, and comprising members from government and industry will identify the marine knowledge and skills necessary to the safe operation of a MODU and will make recommendations which will be the bases for government-industry decisions at the next Council meeting in May 1985. Marine positions identified include:

1. Person in charge
2. First Mate or barge engineer
3. Second Mate or watchstander
4. Chief Engineer, rig mechanic
5. Second Engineer, assistant mechanic
6. Watch Engineer, watch mechanic

A similar committee is addressing non-marine (drilling) occupations found in MODUs and will be making recommendations concerning the training, knowledge and certification for non-marine occupations.

Most oil and gas operators and contractors have unique and proprietary training programs encompassing the elements involved in the process mentioned above. Further development is required to bring about a minimum standard of knowledge and skill for each of the specified positions found on the MODUs, incor-

porating task analysis with minimum standards. This is now being addressed by industry and government through the current consultations.

CCG has been using examinations combined with years of successful experience to arrive at a form of minimum standards to meet the regulations under the *Canada Shipping Act*. The courses for MODU endorsement will incorporate the "task analyses-minimum standards" techniques to ensure that all trainees on the MODUs meet the industry's requirements.

32. That within an appropriate time after the establishment of these standards, no person be permitted to hold a specified position on any drilling unit unless he holds a valid certificate issued by the appropriate authority or an equivalent certificate issued by the authority of another state where the course of training meets Canadian standards. (p. 149)

Implementation Status: (CCG/COGLA/CEIC)

The *Canada Shipping Act* (CSA) applies only to Canadian Flag, self-propelled MODUs. A revised definition in the proposed amendments to the CSA would, if enacted by Parliament, expand the application of Part II (Certification of Officers) to include Canadian Flag non-self-propelled MODUs.

Subject to government-industry discussion at the May 1985 Marine Safety Advisory Council meeting, the training and certification of marine occupations under the jurisdiction of the *Canada Shipping Act* are to be enhanced by the introduction of MODU endorsements which will be required by all certificated marine personnel employed on Canadian Flag MODUs and will also provide for training and experience for these types of vessels. The comments made under Recommendation 31 cover the requirements for training through using task analyses with minimum standards for the endorsements.

The training for the certified drilling occupations on the MODUs that come under control of COGLA will be structured using the "task analyses-minimum standards" technique by having existing training programs developed by the drilling operators-contractors modified to meet MODU requirements. Some drilling companies have already developed these types of training programs. Certification will then become a statement that the trainee has met the minimum standards for each task within the specified occupations. COGLA will have monitored and evaluated the prepared minimum standards, thus ensuring that each certificated employee meets the standards of the industry and the regulatory agencies involved.

Canada recognizes the marine training and certification standards of flag administrations conforming with international tradition and will attempt to promote additional MODU knowledge and skill requirements as mentioned in Recommendation 33.

33. That steps be taken by Canada to promote the establishment of uniform international standards for the certificates referred to in the preceding Recommendation. (p. 149)

Implementation Status: (CCG)

Preparatory work on MODU "marine" occupations is scheduled for completion by May 1985. Canadian and Norwegian delegates attending the IMO Marine Safety Committee's May 1985 meeting intend to submit a joint paper which recommends that the MSC's Subcommittee on Training and Watchkeeping be tasked to study and make recommendations on the training and certification of marine personnel employed on MODUs.

34. That there be a course of training setting standards of knowledge and skill for ballast control operators. That upon successfully completing that course or by demonstrating to the regulatory authority the required skills and knowledge, an individual be granted a certificate to that effect. (p. 150)

Implementation Status: (CCG/COGLA/CEIC)

The master, who has responsibility for the stability of the MODU at all times, is required to have a knowledge of stability for ship shapes and familiarity with piping and pumping arrangements. This knowledge is acquired by a combination of study and experience and is demonstrated by success in a CCG examination.

It is the master's responsibility to ensure that the ballast system is operated by trained and certificated personnel.

Certificated watch officers who may operate ballast systems or supervise the operation are required to have the minimum level of acceptable performance skills.

Knowledge and skill standards for MODU stability and ballast control are currently being developed in consultation with industry. A required course of instruction, based on these standards, is to be established after government-industry agreement is obtained (See response to Recommendation 31). Where the certificated officer described above is assisted by another person, this person must have received training in ballast control in order to be appropriately certificated.

Following final approval of these additional knowledge and skill requirements, holders of marine qualifications will be required to have additional MODU stability qualifications and experience in order to serve on board a Canadian Flag MODU.

The *COGLA Guidelines* require that the person responsible for the safety of a floating drilling unit and its crew be qualified in marine matters, be experienced in drilling operations and possess a recognized master mariner's certificate. They also require that appropriate marine personnel must successfully complete training in ballast control.

35. That the course of training referred to in the preceding Recommendation include, inter alia:

- *a) detailed instruction in the composition and operation of the ballast systems of drilling units;*
- *b) instruction in the appropriate use of the system in emergencies;*
- *c) instruction in all matters affecting the stability of drilling units;*
- *d) instruction in the practical operation of a ballast system by simulator and on a rig itself when available.* (p. 150)

Implementation Status: (CCG/COGLA/CEIC)

The course of instruction and certification standards for ballast control operators will include these four knowledge/skill areas but a simulator may not be used for instruction in all cases.

All trainees will receive practical supervised experience in ballast control operation on MODUs as a prerequisite of the certification process.

36. That within an appropriate time after the establishment of these standards, no person be permitted to hold the position of ballast control operator on any drilling unit unless he holds a valid certificate duly issued by the appropriate authority or an equivalent certificate issued by the authority of another state where the course of training meets Canadian standards. (p. 150)

Implementation Status: (CCG/COGLA)

On Canadian self-propelled MODUs the ballast control and stability of the unit is a responsibility of the master who has training and experience in stability theory and its practice.

The watchkeeper on these units, who may be the ballast operator or supervisor, also has stability training. This training and examination is currently under review with a May 1985 objective for approval, as described under Recommendation 34.

COGLA Guidelines require that the person responsible for the safety of a floating drilling unit and its crew must possess a recognized master's certificate of competency. The Guidelines also require that appropriate marine operations personnel must successfully complete training in ballast control for floating units.

37. That before assuming the position of ballast control operator for the first time on any drilling unit a certificated operator be required to receive orientation in or familiarization with the unique characteristics of the unit's ballast system and operating procedures, and with the alternative method, if any, of operating the ballast system. (p. 150)

Implementation Status: (CCG/COGLA)

The intent of this Recommendation is agreed. This is, however, the responsibility of the master, who is held accountable. (See responses to Recommendations 31, 32 and 34)

38. That the certificate held by a ballast control operator who has not worked full-time in that capacity for an appropriate period of time become invalid on the expiry of that period and that the operator be required to complete a prescribed refresher course in order to validate his certificate. (p. 151)

Implementation Status: (CCG/COGLA)

This Recommendation is being considered during the development of the ballast control operator's qualifications. The requirement for certificated marine officers to demonstrate continued proficiency will become mandatory after proposed amendments to the *Canada Shipping Act* are enacted by Parliament.

The *COGLA Guidelines* will be amended to require that ballast control operators holding certificates or equivalent issued as a result of successful completion of an approved course will also have to complete refresher courses as recommended.

39. That the current COGLA guideline regarding the qualifications of the person responsible for the safety of the drilling unit and its crew be amended to include training in drilling unit operations and in the operation of the unit's ballast control system. (p. 151)

Implementation Status: (CCG/COGLA)

See response to Recommendation 34.

40. That the Offshore Employment Register be scrutinized to ensure that individuals listed for employment on drilling units and support craft are qualified. (p. 152)

Implementation Status: (COGLA)

The federal government agrees in principle with the Recommendation.

41. That the rate of phase in of local residents be controlled, in consultation with industry, to ensure that the highest level of safety is maintained. (p. 152)

Implementation Status: (COGLA)

The federal government agrees in principle with the Recommendation.

42. That periodic exercises be held by industry for the purpose of training its key personnel in what would be required of them in the event of an emergency. (p. 152)

Implementation Status: (COGLA)

Emergency response exercises are being conducted by all operators on Canada Lands both internally as company programs and in other cases with full government participation. In addition, DND has conducted familiarization flights to offshore MODUs that have proven beneficial for DND and the particular operator. COGLA is placing greater emphasis on such exercises with a view to training key government and industry personnel and exercising the cooperative arrangements between offshore operators.

43. That there be an immediate assessment by the appropriate authority of the capability and suitability of the various types of vessels now serving as standby craft to drilling units off eastern Canada to perform adequately their rescue role. (p. 153)

Implementation Status: (CCG/COGLA)

COGLA/CCG in consultation with industry are developing criteria for the suitability and capability of standby vessels and CCG will assess all standby vessels against these criteria. Improved rescue equipment standards and crew training have been adopted and implemented, considerably improving the rescue capabilities of standby vessels.

44. That the primary responsibility of a vessel acting in the capacity of a standby vessel for a drilling unit be to standby within the prescribed time or distance from the unit and be ready at all times to render whatever assistance to the rig and its crew that may be required. (p. 153)

Implementation Status: (COGLA)

Required by *COGLA Guidelines*.

45. That no vessel be permitted to act as a standby vessel if its cargo would interfere with its ability to render assistance to the rig and its crew. (p. 153)

Implementation Status: (CCG/COGLA)

The subject of this Recommendation will form part of the study referred to in the response to Recommendation 43.

46. That there be established training standards for the crew of any vessel which is to be used as a standby vessel and that training embodying these standards be required. (p. 153)

Implementation Status: (CCG/COGLA)

Masters and officers of all standby craft are required to be trained in lifesaving, survival and first aid.

It is the master's responsibility to ensure that his crew is fully trained in the use of all lifesaving equipment on the vessel. Crew training is an important aspect of the MED III course which is required for senior officer certification.

Currently, industry requires training (given in St. John's and Halifax) in the operation of fast rescue craft for crews of standby vessels.

47. That the training embodying these standards include, inter alia, *instruction in:*

a) the use and operation of all rescue and emergency aids with which the standby vessel is equipped;

b) the treatment of survivors for the injuries and other conditions from which they may be suffering upon rescue;

c) the deployment of the standby vessel and its equipment to render effective assistance to the drilling unit and its crew in various emergencies that may occur. (p. 153)

Implementation Status: (CCG/COGLA)

Industry is implementing the recommended instruction.

48. That the crews of standby vessels, while on standby duty, be exercised in the use of the vessels' rescue equipment at least weekly, weather permitting. (p. 154)

Implementation Status: (CCG/COGLA)

It is the master's responsibility to ensure that his crew is fully trained in the use of the rescue equipment on the vessel. Crew training is an important aspect of the MED III course which is required for senior officer certification.

Without taking away that responsibility, COGLA will amend the Guidelines to include a recommendation that the standby vessel crews be exercised in the use of the vessel's rescue equipment at least weekly, weather permitting, while the vessel is on standby duty.

49. That the person in command of the rig and the master of the standby vessel be required to log any occasion when the standby vessel exceeds the prescribed standby time or distance. That where the standby vessel exceeds the prescribed time or distance without the consent of the person in command of the rig, both the person in command of the rig and the master of the standby vessel be required to submit written reports to the regulatory authority. (p. 154)

Implementation Status: (CCG/COGLA)

The *COGLA Drilling Regulations* (section 178(b)) already require that a barge log or ship's log be maintained in respect of a drilling unit, to record the location and deployment of any standby vessel. The officer on watch of the standby vessel would normally record any deviation from established procedures.

Provision will be made in the *COGLA Guidelines* for the submission by operators of written reports to COGLA.

50. That the Rescue Co-ordination Centre in Halifax and the Search and Rescue Emergency Centre in St. John's have available, for instant retrieval, all relevant information with respect to offshore drilling operations on the continental shelf within their respective zones of responsibility that might be required in the event of a marine casualty. That this information include relevant data not only with respect to the drilling units but also with respect to the contracted helicopters and supply vessels. (p. 155)

Implementation Status: (DND/CCG)

All pertinent information concerning the drilling units is maintained at the Rescue Co-ordination Centre in Halifax and at the Marine Rescue Subcentre in St. John's, Newfoundland. Relevant data with respect to the contracted helicopters and supply vessels is maintained by the Flight Watch Centres at St. John's and Halifax and is immediately available to the air and marine controllers.

51. That upon receiving a forecast issuing a storm warning for an area in which drilling units are situated the Rescue Co-ordination Centre at Halifax obtain SURPICs of all ships within a radius of approximately 100 miles of the units every 6 hours commencing 6 hours before the storm is forecast to reach the location of the drilling units. (p. 155)

Implementation Status: (DND/CCG)

At present Rescue Coordinators access the United States Coast Guard Automated Mutual Assistance Vessel Rescue System (AMVER). Also, military operations staffs can advise on the location of navy ships. While these sources are utilized for developing a SURPIC, the most effective and accurate method remains the All Ships Bulletin. It is noted that the requirement to have standby vessels in attendance is intended to reduce reliance on the chance that commercial or naval vessels will be in the immediate vicinity of a drilling rig in distress. All offshore operators have an understanding that their vessels are available to an operator requiring assistance.

52. That the practice of Canadian Coast Guard radio operators waiting for written confirmation of the recorded verbal instructions to issue urgent messages be discontinued. That where personnel at either RCC or SAREC in St. John's are of the view that an urgent message should be transmitted, instructions be issued directly to Coast Guard radio, and, where relevant, the agency giving such instructions inform the other. (p. 155)

Implementation Status: (CCG)

The practice of Canadian Coast Guard radio operators of waiting for written confirmation of recorded verbal instructions before issuing urgent messages has been discontinued.

53. That as a matter of urgent priority Canada complete its SARCUP program to upgrade existing SAR helicopters and obtain others capable of longer ranges and with endurance for rescue missions offshore. (p. 155)

Implementation Status: (DND)

Some study required.

The SARCUP program was completed in June 1984. The range limitations were addressed in the SARCUP program with the installation of external long-range fuel tanks. Range and endurance will be major considerations in future purchases of SAR helicopters.

54. That Canada develop a contingency plan outlining the procedures to be followed in the event of a major marine disaster and that joint exercises be periodically held to train key personnel of SAREC, RCC, industry both on shore and on the rigs and standby vessels in what they would be required to do in the event of rig evacuation under emergency conditions. (p. 155)

Implementation Status: (DND)

National and Regional Major Marine Disaster Search and Rescue Contingency Plans have already been developed in response to a Recommendation in the "Cross Report" (*Report on an Evaluation of Search and Rescue*). The companies involved in offshore exploration have developed their own contingency plans which have been reviewed by DND, CCG, and COGLA officials. These contingency plans have been tested in joint exercises involving personnel from the RCC, the SAREC, the SAR squadrons, and from industry on shore, on the drilling units and on the supply vessels.

55. That when wind speeds are forecast which exceed 90 percent of the design parameters of a drilling unit, the crew from that unit be evacuated before the storm arrives, provided that the evacuation, in the opinion of the person in command of the drilling unit, can be conducted in a safe manner. (p. 155)

Implementation Status: (COGLA)

A guideline to this effect has been in place since December 8, 1983, in the *COGLA Guidelines*.

56. That there be required a full-time search and rescue dedicated helicopter, provided by either government or industry, fully equipped to search and rescue standards, at the airport nearest to ongoing offshore drilling operations, and that it be readily available with a trained crew able to perform all aspects of rescue. (p. 155)

Implementation Status: (COGLA/DND)

Under the December 1983 *COGLA Guidelines*, East Coast Operators are required to provide and maintain, on a continuing basis, a full-time search and rescue helicopter with qualified personnel.

Initial training was provided by DND SAR specialists and further training is available on a continuing basis.

Present Contingency Plans call for DND SAR-dedicated helicopters to deploy to St. John's or Argentia should environmental conditions indicate a critical situation developing on the Grand Banks. These precautions have been supplemented by a number of other lifesaving precautions that make all commercial helicopters and standby vessels more capable of recovering people from the water.

57. That government and industry jointly take steps to ensure that a standardized weather reporting and forecasting system is adopted and understood. (p. 157)

Implementation Status: (DOE/COGLA)

Environment Canada, in close cooperation with COGLA, has adopted well-established international standards which are referred to in Volume 1, page 44, note 2, of the Royal Commission's Report. It is clear from the Commissioner's findings that more work is required in training units to ensure that the information is well understood. Environment Canada and COGLA will address this matter at a meeting with industry scheduled for April, 1985.

58. That when a forecast predicts one or more environmental parameters which require defensive or emergency procedures, and when the required procedures are not in fact taken, a notation to that effect be logged by the person in command of the drilling unit, and a written report be forwarded by the person in command to the regulatory authority within 48 hours setting out the details of the forecast, the established parameter or parameters, the action required to be taken and the reason for not taking that action. (p. 157)

Implementation Status: (COGLA)

The recommended procedure for reporting will be implemented through inclusion in the *COGLA Guidelines*.

59. That the regulatory authority, in consultation with industry, more adequately define, by way of examples, the meaning of the term "significant event" which, should one occur, must be reported to the regulatory authority within the prescribed time. (p. 157)

Implementation Status: (COGLA)

A 1983 meeting between industry and government resulted in the following definition of significant event: "A significant event includes any incident, decision, circumstance, condition or any happening affecting or impacting upon, or resulting from the current operation, that is at variance with the approved drilling program, or with normally acceptable drilling or operational well practices, and is of such importance that the operator's management expects to be informed without delay."

This definition has been refined as follows: "A significant event includes any incident that is at variance with the approved drilling program, or with normally acceptable drilling practices."

This definition amplifies *COGLA Drilling Regulations* section 171 and does not preclude or supersede the reporting of information required under other applicable legislation.

Section 171 requires an operator to immediately notify and follow up with a full written report of an event to the Chief Conservation Officer. The regulation refers to a significant situation or event including the loss of life, a missing person, serious injury to a person, fire, loss of well control, an imminent threat to the safety of a drilling unit, drilling rig or to personnel, an oil or toxic chemical spill or the anticipated discovery of oil or gas.

The revised definition, with examples, will be included in the next revision of the *COGLA Guidelines* due in 1985.

60. That where a drilling unit exceeds its allowable KG at any time, it be deemed to be a "significant event" and a detailed written report and explanation be made by the person in command to the regulatory authority. (p. 157)

Implementation Status: (CCG)

Allowable KG should not be exceeded at any time but an immediate report is required by COGLA in accordance with section 171 of the *COGLA Drilling Regulations* in the event that this "significant event" does occur. The definition of "significant event" as revised by COGLA will provide for this. (See Recommendation 59)

61. That in order to avoid misunderstanding and confusion in reporting procedures there be a single system of measurements used in all reports. (p. 157)

Implementation Status: (COGLA/DOE)

An international system of units based on the nautical mile and the knot is used in marine weather information for Canadian offshore waters. The units of this system conform to the requirements of the Canadian and international marine community. Weather information for general public use on land is expressed in metric units.

62. That the public address and emergency alarm systems each be independent of the other and that each be operable for up to six hours in the event of a loss of electrical generation capability. (p. 158)

Implementation Status: (CCG)

Agreed in principle. Part V, section 45(6) of the *Interim Standards* is being amended to require independent battery power sources for the public address system and the emergency alarm system for a period of one hour for safe evacuation purposes based on the events of the *Vinland* incident. The extension of the one hour period to six hours is being reviewed by COGLA/CCG/Industry.

63. That there be a separate operating manual for the ballast system describing in detail its mechanical, electrical, pneumatic or hydraulic functions and components, its limitations, any alternate method of operation, and instructions for the systematic location of faults and their correction. That it be the responsibility of the person in overall charge of the ballast system to assure himself that the contents of this manual are known and understood by each ballast control operator. (p. 158)

Implementation Status: (CCG/COGLA)

The *Interim Standards* (Part XIV section 99(a)(iii), (d) and (g)) require the details of the ballast system, including its primary and secondary control systems, to be embodied in the drilling unit's operating manual.

It is current industry practice to include such information in the comprehensive operating and maintenance manuals found on board drilling units. These data are examined and approved by the CCG. The introduction of improved training and certification standards for ballast control room personnel (See Recommendations 34 to 38 inclusive) will complement the application of operating and maintenance manuals.

64. That both this operating manual and the Booklet of Operating Conditions *contain detailed instructions for the guidance of ballast control operators and others for operations in other-than-normal conditions, including, but not limited to, intentional slackening of anchor lines; dumping or shifting of mud, drillwater or other weight; breakage of one or more anchor lines; accidental flooding of various combinations of lower tanks; accidental flooding of one or more chain lockers and spaces in the upper hull; and inclination of the rig because of second order wave effects.* (p. 158)

Implementation Status: (CCG/COGLA)

The manuals already provided to units contain detailed instructions on most aspects of the unit's operation. Additional items for inclusion will be discussed at the May 1985 meeting of the MSAC Offshore Subcommittee with a view to including them in the Operations Manual requirements contained in Part XIV of the *Interim Standards*.

65. That ballast control operators be required to calculate and log the drilling unit's transverse and longitudinal angles of inclination weekly. That where the calculated moments of either are in excess of 1,000 foot tons from the actual moments (as determined by the inclinometers) the amount of the variation be entered in the log and contained in the next morning report. (p. 158)

Implementation Status: (CCG/COGLA)

The stability of a column-stabilized drilling unit is monitored and documented continuously to ensure compliance with the allowable KG curves in accordance with Part III section 22(1) of the *Interim Standards*. In addition, the *COGLA Drilling Regulations* (section 177(c)) requires the calculation of a column-stabilized drilling unit's KG at least once every 24 hours.

A drilling unit which exceeds its particular allowable KG is to document such an event as a "significant event" (See response to Recommendation 59). Additionally, the stability of the drilling unit is examined during each annual, biennial and quadrennial inspection as prescribed by the *Interim Standards* (Part I section 8(2)(c), (3) and (4)(b)).

66. That the primary control centre for the ballast system on a drilling unit be manned and attended at all times. (p. 158)

Implementation Status: (CCG)

Agreement has been reached with industry that a 24-hour watch will be maintained.

DESIGN AND CONSTRUCTION APPENDIX C

APPENDIX C

DESIGN AND CONSTRUCTION

ITEM C-1

THE MODU DESIGN PROCESS

An extract from:

An Essay on the Design of Mobile Offshore Drilling Units
Earl and Wright
Consulting Engineers
May, 1984

The major participants in the design, construction and operation of an offshore drilling unit have, at various times and in various capacities, direct impact on the quality of the unit. The primary participants are the owner, designer, builder, drilling contractor, operator, classification society, and regulatory agency. One organization may fill more than one of these roles. Due to the number of participants and the complexity of the overall process, it is easy to visualize breakdowns in communications and disagreements on the interpretation of technical and regulatory requirements. These potential problems may be further compounded by the various combinations of participants. Tables 1 and 2 illustrate two case studies which highlight the potential discontinuities that can occur.

Table 1 represents an extreme but realistic situation which has numerous possible gaps or discontinuities throughout the process. In this case, the rig is designed by an independent designer who has no further involvement after the design is sold to a builder. The unit is built on speculation, and is subsequently purchased by an owner who obtains a Certificate of Fitness to operate in a jurisdiction not covered during the design and construction process. The owner leases the rig to a drilling contractor under a "bareboat" charter. This scenario requires several independent parties to interpret separately the technical data and drawings necessary to build and operate the rig.

Table 2 represents a situation which minimizes the possibilities for discontinuity throughout the entire process. The owner, designer and drilling contractor are all representatives of the same firm, which also provides for members of the design group to be present at the shipyard during construction. The unit is designed for specific operators, and the operators' input is included in the design. The rig is classed and certified during design and construction for operation in a designated drilling area.

TABLE 1
Case Study One

PROCESS	OWNER	DESIGNER	BUILDER	DRILLING CONTRACTOR	OPERATOR	CLASS. SOCIETY	REGULATOR
Concept	■				■		
Design		■				■	■(3)
Build			■			■	■(3)
Drilling	■(1)			■	■		■(3)
Maintenance				■		■	
Repair				■		■	
Modification	■	■(2)				■	■(3)

NOTES:
(1) Bareboat charter to drilling contractor.
(2) May not be the original designer.
(3) May be more than one regulatory agency.

TABLE 2
Case Study Two

PROCESS	OWNER	DESIGNER	BUILDER	DRILLING(1) CONTRACTOR	OPERATOR	CLASS. SOCIETY	REGULATOR
Concept	■				■		■
Design	■	■		■	■(3)	■	■
Build	■(2)	■(2)	■	■		■	■
Drilling	■			■	■		■
Maintenance	■	■		■		■	
Repair	■	■		■		■	
Modification	■	■		■		■	■

NOTES:
(1) Owner, designer, and drilling contractor are the same organization.
(2) Owner has shipyard team.
(3) Unit designed for specific operators.

TABLE 3
Overview of Design Procedure

PHASE	PROCEDURE
Concept	Establish provisional criteria Develop conceptual configuration Analyse for stability and motions Analyse for structural feasibility Refine configuration Document conceptual design
Design	Establish operating criteria with client Develop design basis for client approval Develop preliminary design for client approval Obtain regulatory approval in principle Develop final design Analyse for strength, fatigue, and damage Refine final design Obtain regulatory approval Issue design document for construction bids
Construction	Select fabricator and issue contract Approve proposed construction method and schedule Prepare documentation for owner-furnished equipment Approve shop drawings Obtain regulatory approval for shop drawings Establish inspection team for construction Commence construction supervision Approve equipment testing Approve inclining test, dock, and sea trials Issue final design and operating documents
Operations	Receive feedback from operating personnel Evaluate operations information, provide assistance as required Evaluate repair, modification, and certification requirements as necessary, provide assistance as required Document all repairs and modifications Update design and operating documents

Many advances in MODU design have been brought about by the extension of drilling into deeper water and more severe environments. In many cases, designers extended or modified existing designs until the limit of extrapolation was reached and the basic configuration could no longer be utilized. With the discovery of oil in the North Sea came the trend for designers to produce larger, "world class" MODUs with increased fuel, consumable and equipment capacities to minimize the resupply costs associated with exploratory drilling in remote areas. For instance, the SEDCO 135 series semisubmersible introduced in 1965 had a deck load capacity of approximately 1,250 metric tonnes; current designs, such as the GVA-4000 have a deck load capacity in excess of 4,000 metric tonnes. The changes in configuration brought about by increased functional requirements and environmental limits have been the principal mechanism for the evolution of MODU designs.

Table 3 and Figures 1 to 4 provide an overview of the design procedure for a new semisubmersible drilling unit, from conceptual studies, through design and construction, to the operational phase. The information is based on the experience of Earl and Wright, Consulting Engineers and their parent company, SEDCO Inc., and does not necessarily reflect an industry standard. Although these figures imply a well-defined boundary between each activity, time constraints often dictate an overlap between steps and phases.

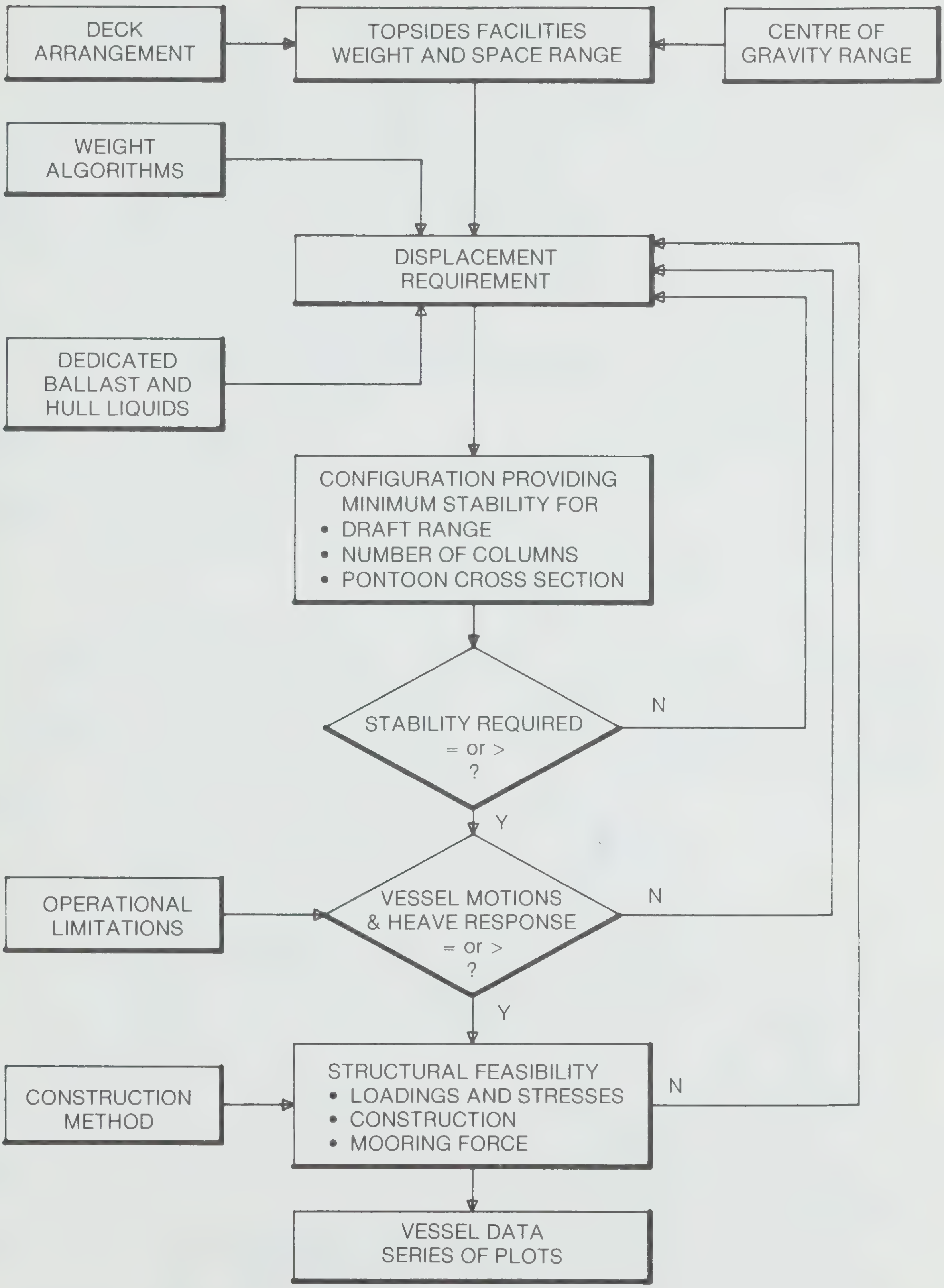

Figure 1 Conceptual Phase

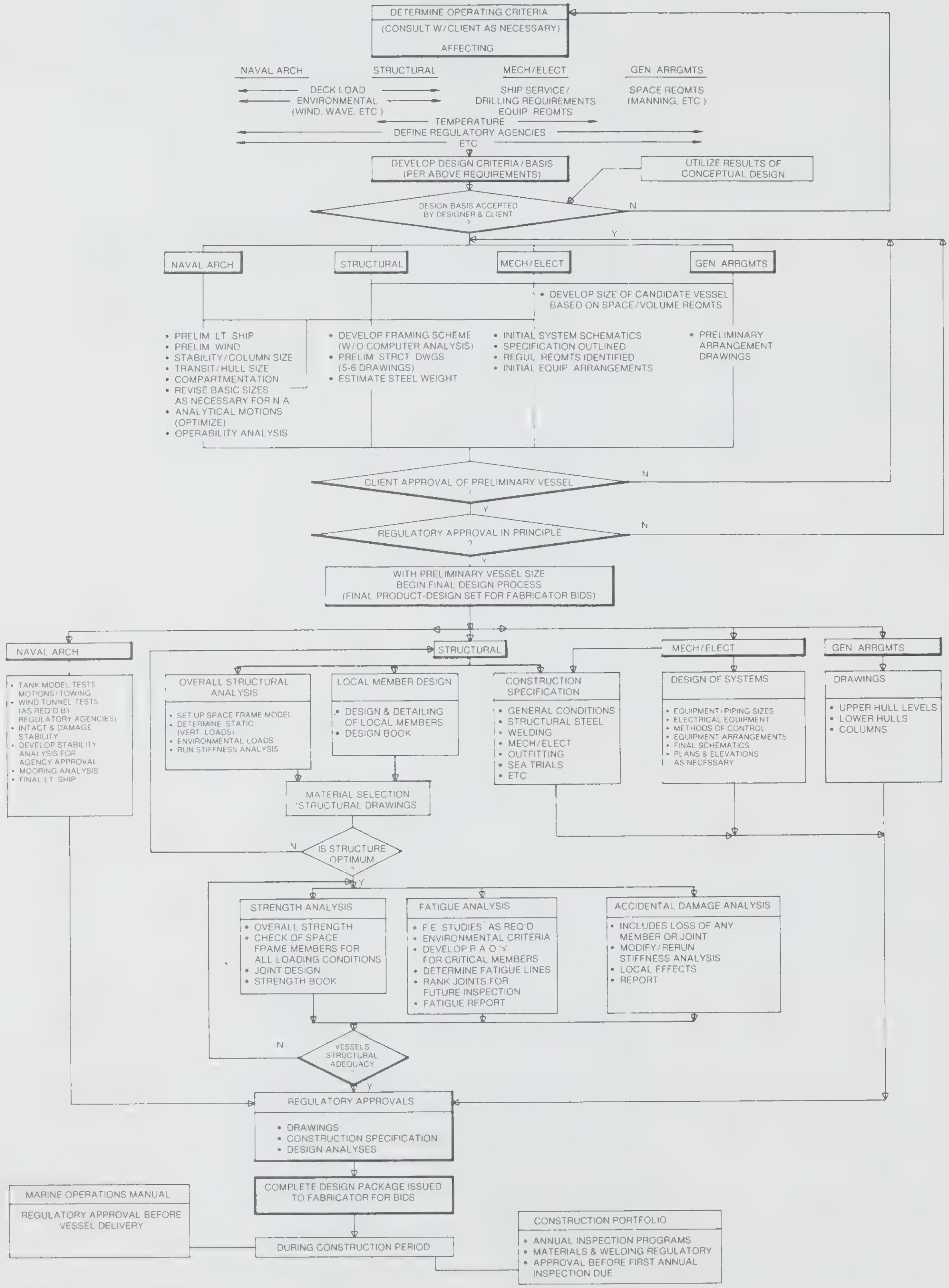

Figure 2 Design Phase

[1]FE = Finite Element

[2]RAO = Response Amplitude Operators

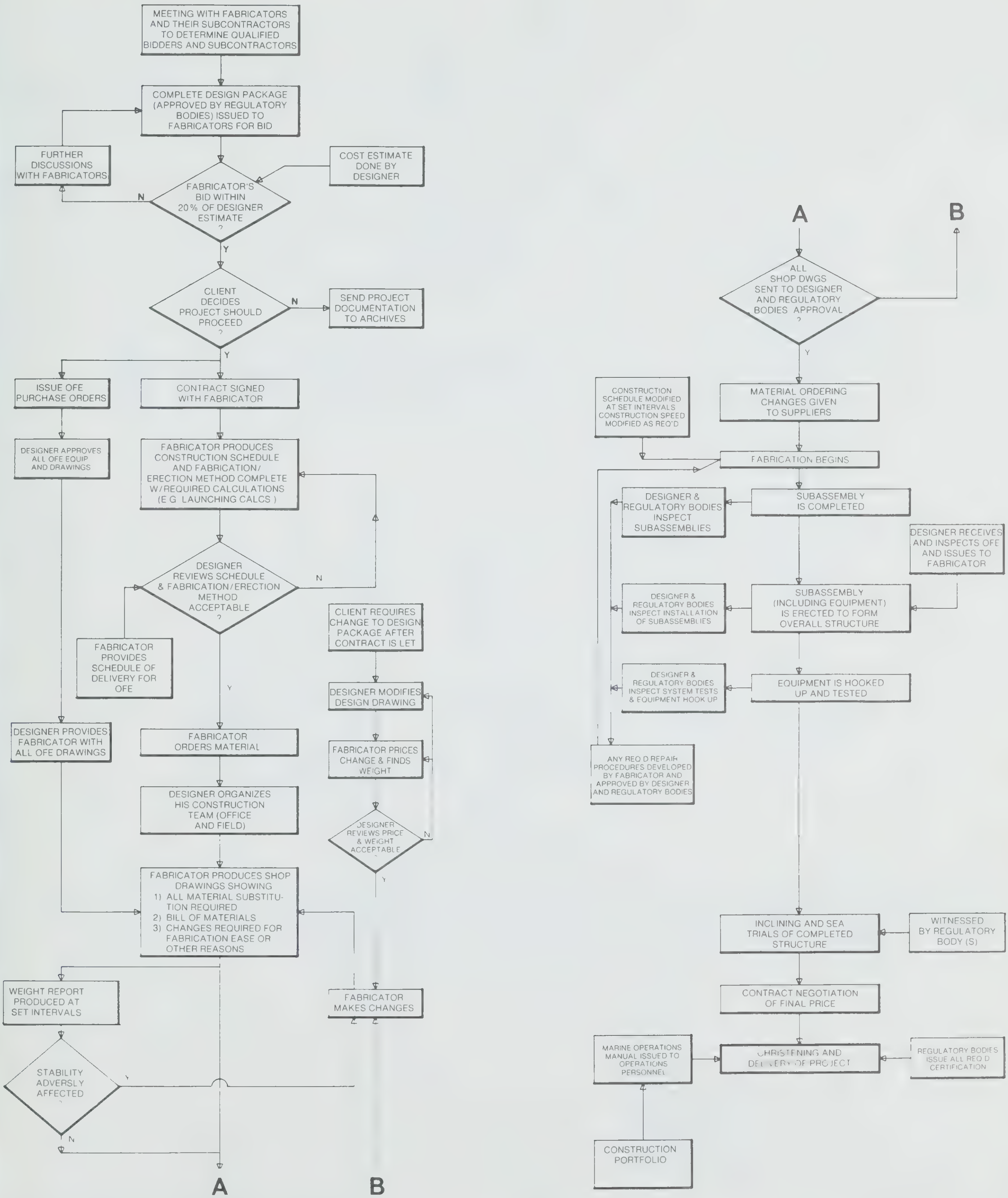

Figure 3 Construction Phase

[1]OFE = Owner Furnished Equipment

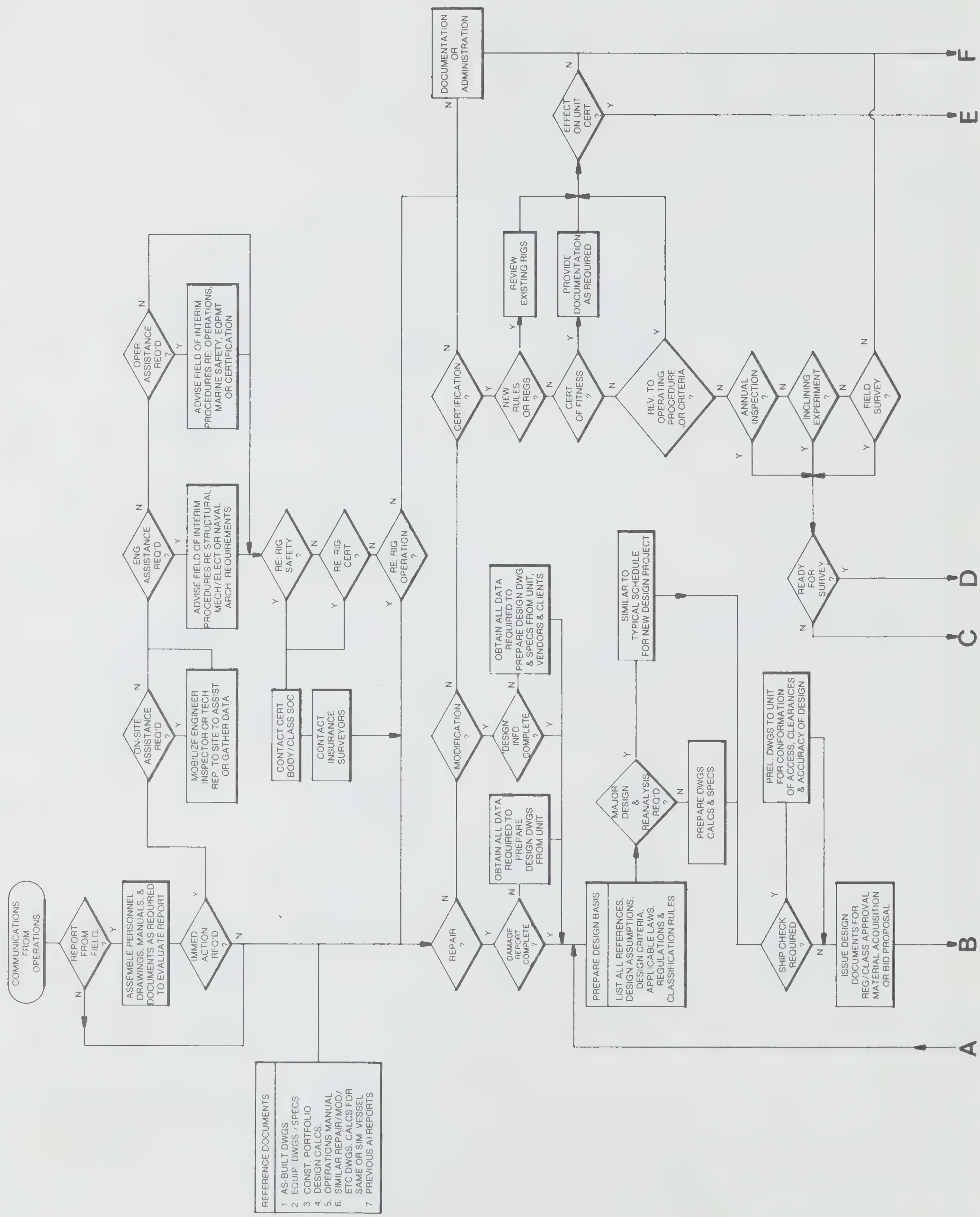

Figure 4 Operations Phase

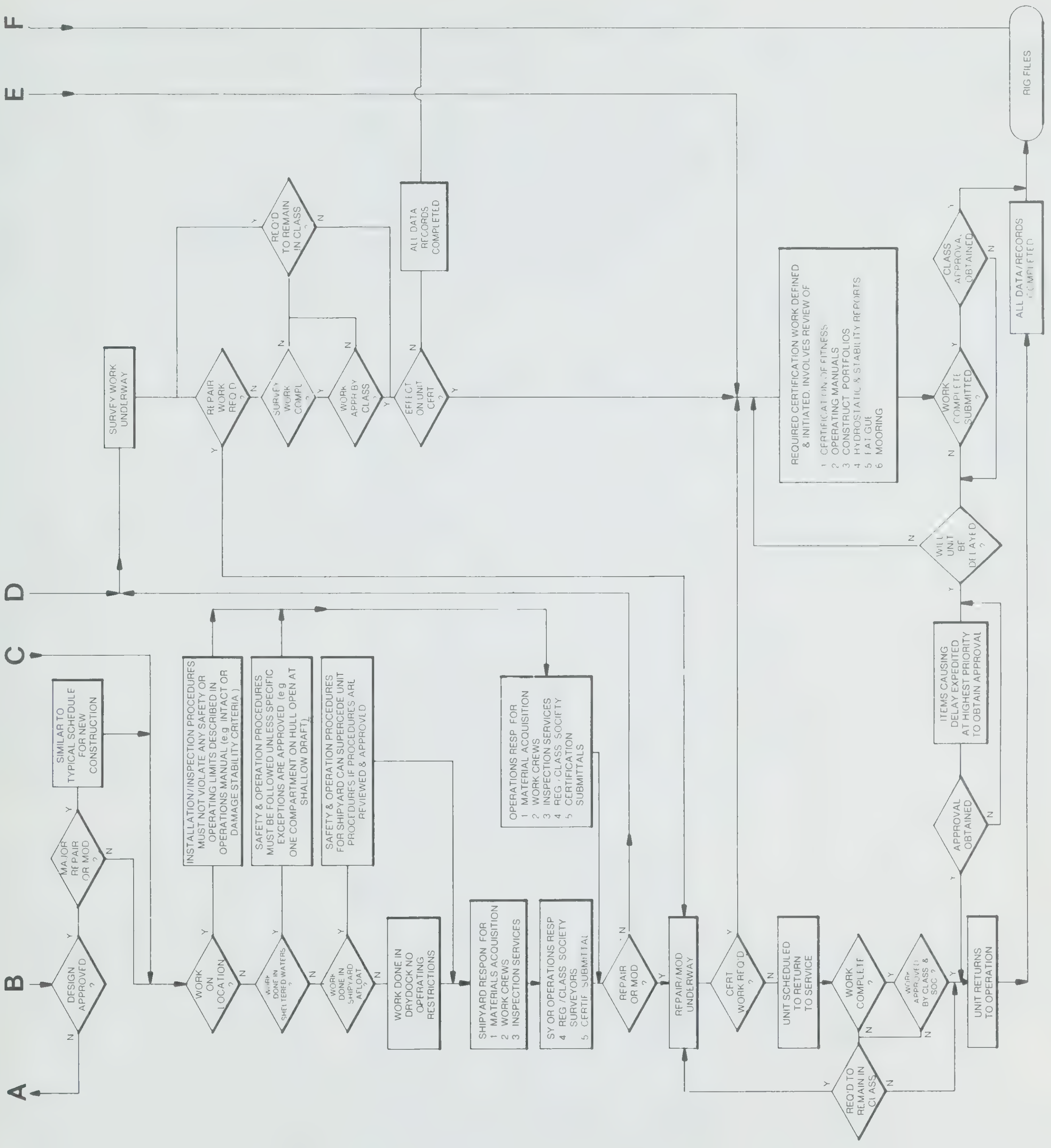

Figure 4 Operations Phase (continued)

ITEM C-2

HYDRAULIC MODELLING OF OFFSHORE STRUCTURES

Hydraulic Modelling of Offshore Structures: Concerns for the Description and Simulation of Environmental Conditions
July, 1984

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INTRODUCTION

In the course of the hydrodynamic and aerodynamic model studies of the *Ocean Ranger*, there was cause to question many aspects of the present knowledge of environmental conditions and also the methods used to simulate the environment and to determine loadings on offshore structures. Since the model studies were conducted to find how the *Ocean Ranger* could have capsized, it was essential to model wind and wave conditions as closely as possible. The main conclusions from the tests were reliable, but it was quickly discovered that although detailed prototype measurements were available, they did not provide adequate information concerning a number of parameters which could have been important. This paper is not specifically concerned with the *Ocean Ranger* model studies.[1] It addresses more general concerns regarding future requirements for hydraulic model studies on offshore structures, and the necessary description of the environment to enable performance of such studies.

DESCRIPTION OF THE ENVIRONMENT

The process of design of an offshore structure involves thorough investigations of the predicted loadings on the structure due to wind, waves, currents, and ice. However, when we try to define any of these environmental factors, it is found that there are difficulties and that we do not always understand what characteristics are important in producing adverse responses in a structure. Although existing methods of describing the environment may be satisfactory for some situations, there remain gaps in present knowledge which can lead to potentially serious omissions in the design process.

Waves

For many years it was considered adequate to represent ocean waves as simple sinusoidal waves in both physical and mathematical models. However, since hydraulic laboratories first began model testing with irregular waves, many characteristics of full-size waves have been found to have important consequences in model tests. For example, instead of the irregular sea state being of uniform intensity, large waves may arrive in groups. Extreme wave groupings, like extreme wave heights, are chance occurrences which may have a small but finite encounter probability. Nevertheless, because of their potential for significant structural response or damage, they must be given adequate consideration.

Associated with wave groups are long waves which occur because of a mean set-down of the water surface under a group. These long waves can also be important in exciting low frequency responses of offshore structures. However, as most wave observations have been made by floating accelerometer buoys which do not respond to these low frequencies, little first-hand knowledge is available.

The asymmetry of real ocean waves is another important characteristic. It is speculated that wave asymmetries will affect total loads on structures, impact pressures, wave run-up and the clearance between wave crests and deck level. Again, it has been found that the accelerometer buoy does not correctly record the asymmetry of waves. It usually indicates that the rear of a wave crest is steeper than its front and this is known to be incorrect.

Most hydraulic model tests are conducted using long-crested waves generated by a wave machine with one long rigid generator board. Recently, however, wave generators have been developed with segmented generator boards, which are individually controlled such that it is possible to reproduce short-crested, multidirectional seas in laboratory test basins. The use of multidirectional seas in hydraulic model tests will mean that wave loading and structural response can be more correctly reproduced. In addition, deck clearance and wave slamming on the underside of drilling platforms can be better modelled. Paradoxically, now that this capability exists, directional ocean wave measurements are still almost non-existent.

Recently there has been a growing suspicion that the accelerometer buoy does not accurately record the maximum wave height in a short-crested sea, perhaps because of its tendency to slide away from the highest surface elevation in the relatively narrow width of the wave, or because it submerges rather than rides above the crest of an extreme wave. It is known from visual observations that episodic waves of extreme height occur, and have caused severe damage to a number of ships, but such waves have never been recorded by accelerometer buoys. It is also thought that episodic waves recur in specific areas where shoaling and superposition of waves from different directions may lead to amplification.

Ocean Currents

More information regarding ocean currents is necessary not only because of the direct effects currents have on offshore structures, but also because of the interaction of currents with waves. For example, waves opposing a current become steeper and

may break. Measurements of wave heights are generally made without regard for the possible presence of ocean currents, so that ocean wave/current interaction is not well understood.

The currents usually of concern in engineering design are tidal currents, and wind-induced currents which are due to wind shear on the sea surface. Current velocities are added vectorially to the water particle velocities of the waves to determine wave loads, but recent research indicates that when the current opposes the waves, this method underestimates the loads.

Wind

Examination of the power spectral density functions of natural wind turbulence and of ocean waves shows that the energy in wind occurs at much lower frequencies than it does for waves. If the frequencies for the natural modes of vibration of semisubmersibles and other types of offshore structures are superimposed on the two spectra, it is found that they fall below the range of frequencies for the wave energy but coincide with the range of frequencies for the wind energy. It follows that dynamic response of such structures to wind turbulence could be a significant factor in consideration of the combined effects of wind and waves.

Basic to the determination of the wind response of a structure is an accurate probabilistic description of the extreme winds to which the structure would be exposed. While detailed measurements have been made over the sea surface, they have been concentrated mainly at very low heights. On the other hand, for winds blowing over land, more extensive measurements have been made that provide this information for a variety of terrain conditions. There is also a limited amount of land-based measurements for winds blowing off the sea. However, this information cannot be applied directly to open sea situations because of the different surface conditions. In the case of wind blowing over the sea, the sea state has an important influence on the wind properties and vice versa. For the rougher seas, which would be associated with high winds, the turbulence intensity would be higher. Also in wind/wave interactions there may be a strong relationship between wind gusting and wave grouping.

It is important that there be an ongoing effort to obtain detailed information on wind properties including the vertical distribution over waves and the turbulence characteristics.

Ice

Significant advances have been made in recent years in the study of ice and its effect on marine structures. However, our present knowledge is inadequate and could not ensure the integrity of many offshore structures were they to encounter severe ice conditions. More measurements of the mechanical properties of sea ice and iceberg ice are important, particularly if gravity platforms are to be situated on the Hibernia field. Although the compressive strength of ice has been reasonably well described at low strain rates, there are very few good measurements at the relatively high strain rates consistent with an iceberg impacting a gravity platform. Fracture toughness measurements are also needed in order to predict the tendency of the ice to fail by crack propagation. It is also important to continue investigations into the frequency of occurrence of icebergs, the sizes, shapes, stability and velocities of icebergs, and the prediction of iceberg movements. More information is also required on both the large-scale morphology and microstructure of the ice.

The accretion of ice due to salt spray and freezing rain is also a problem to be considered for offshore structures situated in extremely cold waters. Icing on small vessels is a well-known problem, but this experience cannot automatically be utilized for offshore structures due to the large differences in dimensions and geometry. Theoretical models exist for the calculation of ice accretion, but these need to be verified through full-scale measurements and ice tunnel tests.

HYDRAULIC MODEL TESTS

Most of the recommendations we would make here concern uncertainties that exist in present practices in model testing, and therefore involve research efforts required to identify the needs for more sophisticated modelling techniques.

Waves

For many years it was considered that it was sufficient to generate irregular waves in the laboratory satisfying only a spectral description which was either theoretical or measured. However, it is now known that the wave spectrum alone does not describe all the characteristics of irregular waves which are essential in testing offshore structures. Therefore, in the generation of long-crested irregular waves there are now requirements to simulate wave grouping and wave asymmetries, and to control spurious long

waves in test basins, as well as to satisfy the traditional spectral wave parameters. However, there are very few laboratories with such sophisticated wave generation facilities.

From a safety point of view it is also important to investigate the most extreme conditions. Methods have been developed to generate large plunging breakers in which both the wave characteristics and the point of breaking may be controlled. However, in order to simulate realistic extreme wave conditions, more feedback from full-scale measurements is required.

It is also considered that a serious deficiency in hydraulic model testing has been the inability to simulate multidirectional seas. At present, although we are not even able to describe very well what directional seas we should be simulating, a number of laboratories have installed or plan to install, segmented wave generators for this purpose. It is believed that short-crested seas will have a significant effect on the wave loads on structures, the response of floating platforms, wave run-ups, slamming loads, and deck clearances.

In consequence, further research should be performed to evaluate the importance of non-conventional sea-state simulations for the loading and response of offshore structures.

Ocean Currents

Few testing laboratories are equipped to simulate wave and current interactions (NHL is one of the few). Possibly the reason for this is the high cost of the necessary equipment, the difficulty of controlling velocity profiles in the presence of wave machines and beaches, and the uncertainty of the significance of the effects of currents, particularly when there is generally a paucity of data concerning ocean currents. It is considered that research efforts should be directed to the wave and current interaction problem to ascertain if ocean currents should be simulated in hydraulic model studies on a routine basis.

Wind

The principal question to be addressed is the importance of simulating fluctuating wind loads on a model of a floating offshore structure. Estimates of dynamic response at typical design wind speeds have suggested that for some semisubmersible drilling platforms the root-mean-square pitching motions due to wind could be of similar magnitude to those arising as a result of wave action in typical design sea states. Model tests can be used to answer this question, but it is first necessary to describe the wind loads to be simulated, and then to establish a satisfactory simulation technique to be used in the hydraulic model tests.

A literature review has uncovered no examples of hydrodynamic model experiments that include simulated atmospheric winds for the purpose of reproducing the dynamic response to wind turbulence. It is also apparent that the standard practice for wind tunnel experiments has been to measure only the average or mean drag forces and overturning moments. Very few tests have been conducted in which vertical forces have been measured, and no available studies have concerned themselves with determining the unsteady or dynamic component of wind forces.

In hydraulic model tests, fluctuating wind loads may be simulated by different methods. One method is to use a bank of fans blowing over the waves and a model of the floating structure. Mean and fluctuating wind loads are simulated by regulating both the mean speed of rotation of the fans and a superimposed sinusoidal fluctuation. The system is calibrated on the basis of forces and moments measured in wind tunnel tests. During calibration the model is kept fixed at a given draft, angle of heel and heading. The speed of rotation of the fans is then regulated until correct forces and moments are achieved. The disadvantage of this method is that it may be difficult to control low frequency gustiness due to natural fluctuations in the building. This problem may possibly be overcome by building a tunnel over the testing site. However, assuming that scale effects are not too severe, the method will simulate the effect of wind loads on an oscillating platform in waves.

A second method of simulating wind loading is by applying the loads as measured in a wind tunnel, by a high precision servo-mechanical control system through light-weight lines attached to the model. Computer controlled motors fluctuate the forces in the lines to simulate the wind loads according to the instantaneous attitude and draft of the model. This method satisfactorily reproduces the low frequency content of the wind spectrum, but has the possible disadvantage of only being practical for simulating loads in three degrees of freedom on structures which are moored. It is also necessary in this case to measure loads in the wind tunnel over the complete range of possible drafts, and angles of pitch, roll and yaw. A sophisticated control system using instantaneous measurements of motion of the model is essential. The simulation of wind loads by this method is not practical if the angles of trim vary considerably during the course of a test.

The technology already exists for the wind tunnel simulation of the natural wind surface layer and it is now routine to use these simulations to determine the dynamic loads and dynamic behaviour of tall buildings, long span bridges and other land-based structures. These techniques can be applied directly to the measurement of the fluctuating wind loads on offshore structures, although a suitable approach to modelling the time-dependent sea surface needs developing. With the size of wind tunnels that are available, the model scale ratio would be in the range 1:100 to 1:400.

On the other hand, the direct inclusion of the wind in wave basin studies presents some fundamental difficulties. In particular, the scale of the hydrodynamic model should be at least 1:40, while it is unlikely that all of the properties of the wind could be reproduced at a scale larger than about 1:100. This limitation on the scale of the wind simulation arises as a result of the desirability of modelling the full depth of the surface wind layer which would be at least 300 metres. One consequence of a mismatch of the two scales is that the model-scale frequencies of the wind energy and the wave energy might not both be correct with respect to the scaled natural frequencies of the modelled structure. Research is needed to develop techniques that will obviate this incompatability and resolve other experimental problems such as that of having different wind and wave directions.

Considerable further effort is necessary to study the effects of wind loading on offshore structures and to determine the importance of routinely simulating fluctuating wind loads during hydraulic model tests of floating offshore structures.

Ice

The possible interactions of icebergs with gravity drilling platforms are extremely important, but to date very little research has been conducted on this subject. Methods for protecting gravity platforms from icebergs such as berm structures, methods of deflecting icebergs, or structural designs to facilitate the crushing or splitting of impacting icebergs, have not been thoroughly tested in the laboratory. One major problem has been the lack of model iceberg ice which correctly simulates both the crushing and splitting mechanisms of ice. This is required to ensure that the ice loads on the structure are correctly modelled. To date, there has been very little effort in this area and no material currently exists which satisfactorily simulates the characteristics of iceberg ice at model scales.

Not only are large icebergs dangerous, but the smaller bergy bits which are not easily observed in waves, can move at approximately the same velocity as the water particles in the waves and therefore can cause considerable damage if they impact structures with slender members, such as semi-submersibles.

Although accretion of ice is expected to cause operational problems such as slippery gangways and falling ice, one should also bear in mind the influence that severe icing may have on stability, motion response, etc.

Environmental Forces and Scaling Problems

We have discussed the importance of modelling the environmental forces. However, when performing model tests with simulations of these forces, we are still limited by the traditional model scaling problems. These are hydrodynamic problems such as damping, viscous flow and drag, which are associated with low Reynolds numbers. Some of these problems are exacerbated when a number of individual environmental forces are modelled simultaneously, and can therefore result in incorrect motions of a structure. For example, if waves and currents are modelled together, there are increased damping and viscous flow dependent forces which cannot be modelled precisely because of the inability to satisfy the Reynolds number similarity law.

The total effect can be taken into account by estimating the contribution from each hydrodynamic phenomenon. For example, the damping problem is most significant at resonant frequencies, which are excited by second order effects. By summing contributions from all effects, including that of currents, correct full-size motions can be estimated.

NUMERICAL MODELS

There is a tendency for designers to rely heavily on numerical models because they are relatively inexpensive to run and not as time-consuming as a series of physical model tests. However, many numerical models are still deficient in several regards, so it is essential that these are improved to give adequate solutions to a number of problems.

In general, the existing (linear) numerical tools give reasonably good results when analysing structures with "normal" geometry in "moderate" sea states (moderate loading and motion responses). The operational capabilities of conventional structures may therefore successfully be determined by numerical analysis.

The safety of offshore structures is, however, mainly dependent on the extreme con-

ditions to be encountered during the lifetime of the structure. These extreme conditions are in general very complex and thus difficult to model theoretically. The following list should therefore serve as examples of problems requiring further development of numerical modelling:

- Motion response of structures with extreme geometry, such as large variations of water plane area with depth.
- Non-linear global wave loading, including effects of extreme wave heights, wave asymmetries, breaking waves, low frequency responses to wave grouping and wave drift forces, as well as local wave loading, slamming, and interaction effects due to wind, waves, and currents.
- The response of floating structures to fluctuating wind loads.
- The response of damaged platforms to wave loading.
- Wave run-up and deck clearance in extreme wave conditions.
- The drift movements of icebergs and the response of structures to impact by icebergs or bergy bits.

CONCLUSIONS

Offshore structures will be used wherever there is the possibility of discovering and exploiting ocean resources such as oil, gas, and minerals. The most adverse offshore environment of waves, wind, ice, or water depth is never seen as an insurmountable obstacle. Thus, there is continuous development of new designs of offshore structures to cope with severe environmental conditions, to be as inexpensive as possible and to allow maximum operation time. To ensure the safe operation of these structures is a challenge; it is therefore essential that we continue to learn about the offshore environment and that we develop improved simulation techniques for both physical and numerical models.

In the future, it is expected that the principal applications of physical model tests will be the following:

- The investigation of new types of offshore structures for which response is dominated by physical effects that are difficult to model numerically.
- The verification of numerical models and the definition of input parameters for numerical models.
- The simulation of complex marine operations.
- The simulation of complex environmental conditions.

[1]An examination of the aerodynamic and hydraulic model testing carried out in support of the investigation is found in Appendix F, Item 5, *Report One: The Loss of the Semisubmersible Drill Rig Ocean Ranger and its Crew*.

ITEM C-3

CRITICAL SYSTEMS

A critical MODU system is one which may affect the structural integrity, stability, seaworthiness or safety of the unit. Such systems, because of their potential impact on human life, merit careful consideration by designers, operators and regulators.

For drill ships, semisubmersibles and jack-ups the central critical system is the structure itself, the design of which is governed by a wide variety of functional and operational requirements. Global and local stress analyses are performed on the structure to ensure that it is able to stay intact under a number of extreme combinations of environmental conditions. Particular attention is paid to high stress locations and those areas that may be influenced critically by fatigue loading. The partial or total loss of, or damage to, load-carrying members is also analysed for its effect on the integrity of the structure. Such special analyses, proper quality assurance throughout the construction process and during any subsequent modifications, and a program of structural performance and integrity monitoring should guarantee the integrity of the structure during its lifetime.

The intact and damage stability of drill ships and semisubmersibles at all drafts and of jack-ups while under tow or while pre-loading the legs, depends critically upon ballast systems. The loss of a MODU's stability may be due to: damage caused by collision with other vessels, with sea ice or icebergs; fire or explosion; downflooding; watertight compartment damage; failure of the ballast control system; and changes in structural loading including superstructure icing. Mechanical or electrical failure of the ballast control system or human error in operating that system may precipitate a change in trim or heel. It is also possible that other circumstances may lead to an initial trim or heel of the MODU and that a subsequent failure in the ballast system will preclude the possibility of recovery. The necessity for all components of the ballast system to remain operational when the structure is damaged or flooded is of critical importance. There is, of course, a complicated relationship between loss of structural integrity and loss of stability of a MODU. A collision may result in structural damage that causes flooding of watertight compartments, which may in turn lead to partial or total loss of stability. A fire or explosion may also result in a partial loss of structural integrity and a subsequent, partial or total loss of stability. Conversely, ingress of water through the sea chest or through any non-watertight opening in the structure (chain-lockers and other downflooding points) may result in a partial loss of stability followed by some structural damage and a final, total loss of stability of the MODU.

There are a number of other critical systems that are common to all MODUs. These include well and fire control systems; primary and emergency electrical power systems; alarm and communication systems; and evacuation systems. Here again, these critical systems are interrelated; a loss of well control may necessitate the use of fire control systems which rely on electrical power. Alarm, communication and emergency power systems may all be required for the successful use of evacuation systems. Certain critical systems are inherent in only some types of MODUs. Positioning systems and mooring systems are applicable to drill ships and semisubmersibles whereas jacking/holding systems are critical systems unique to jack-ups.

The essential point to bear in mind while analysing critical systems is that it is necessary to postulate a wide range of credible accident possibilities against which total system adequacy may be gauged. Many components of the critical systems which form an integral part of the MODU itself are covered by classification society rules, as are basic performance requirements for some of the systems. There are, however, many important features which are not addressed by classification societies and must therefore be dealt with by the designer of the systems, preferably in close co-operation with the owner of the rig.

During the design process, or at a later time if missed during this process, each critical system should be examined for the probability of failure of individual system components and the severity of the consequences of such failures. Steps should then be taken to eliminate or at least reduce the probability of failures which are sufficient to endanger the ultimate safety of the unit. The examination can be carried out as a "risk analysis", which is now a well-established procedure for identification of failures or design weaknesses, but other methods are also available. Ideally, this type of analysis will be an ongoing process spanning the life of the rig, as changes in operator procedures and competence, modification and degradation of equipment and the effectiveness of repair/maintenance procedures will have a continuing impact on overall risk levels.

A system, by the definition used here, consists of the integration of equipment and materials, which when operated by personnel performing the correct procedures will perform a specific function. The simplest system will consist of a process necessary to carry out the required function, a means of exerting control over the process and a means of determining the condition of that process. Each element in the system and the interconnections between them must be

planned carefully so that the effect is complementary to the system as a whole and so that the probability that the system will fail is minimized. As the complexity of the system increases, achieving this goal will require an increased level of effort.

In the design of MODU systems, the designer will seek inherently reliable components and will endeavour to provide some margin of safety to account for excessive loading or operational effects caused by unforeseen circumstances. Nevertheless, in recognition of the fact that even reliable components are subject to failure, and that the system may not be sufficient to account for all adverse cases, a number of other design principles may be applied in order to reduce the probability or consequence of a failure. Perhaps the most familiar of these principles are those of redundancy and diversity. Redundancy allows the performance of the same overall function through independent, but identical, means; diversity allows the performance of the function through independent and different means. Many systems combine both principles to achieve greater reliability. An example of such a system is the subsea blowout preventer (BOP) stack installed on the well head to maintain control over high-pressure conditions which may be encountered during drilling from a floating MODU. The potential consequences of a loss of well control (i.e. blowout, fire, explosion, toxic gas release), coupled with the inaccessibility of the stack for repair and maintenance, has lead to the incorporation of several levels of redundancy and diversity to prevent failure.

Another principle incorporated in many systems is that of "failure to safety" or fail-safe design. A fail-safe design attempts to ensure that, in the event of failure, the system enters the least hazardous of possible failure modes. An example of this principle is the typical arrangement of valves on sea suction lines associated with ballast systems. In the event of a control or power failure the valve is designed to close automatically, thus preventing an uncontrolled ingress of water and the potential consequences of such an ingress. The term "fail-safe" has sometimes been assumed to imply that the system will tolerate operator errors without causing an unsafe condition; as noted in Report One of the Royal Commission, this misconception may have lead to complacency in the selection and training of ballast control operators on the *Ocean Ranger*. Most fail-safe features may be bypassed or overridden through operator intervention, and the competence of the operator to evaluate the consequences of such action is of great importance.

The operator closes the loop between the control process and monitoring elements of the system. On the basis of information received from the monitoring equipment, the operator determines the status of the process; if changes or adjustments are necessary, the control equipment is employed to bring the process to the desired state. It is important that the operator receive a clear indication that the commands issued through the control equipment have been carried out correctly, and that the process has reacted in the expected manner. This can only be achieved if the control and monitoring elements of the system are independent of each other. It was determined during the Royal Commission's investigation into the loss of the *Ocean Ranger* that the control and monitoring elements for the ballast system valves were interconnected through relays in the control panel. Under certain circumstances, such as the failure of a valve to open or close on command, the operator would consequently be presented with confusing information, which could be interpreted as being the result of any one of a number of minor and major faults. In a similar manner, although the ballast valves could be controlled by the manual activation of solenoids housed inside the panel, the monitoring equipment could not properly reflect the changes in valve status brought about by this alternate means of control.

The design principles incorporated in the "man-machine interface" of critical systems are of equal importance to the design of the hardware. The complexity and variability of the human operator has often been used as an excuse to forego the active assessment of human factors in design. Nevertheless, design principles have emerged which allow these factors to be addressed in a formal, albeit somewhat subjective, manner. These relate primarily to the display of information, the relationship between the control system and the monitoring system and the layout of the equipment and the working space.

It is clear that if information is not presented or displayed with due regard for the characteristics of the human brain and body, then the information may be misinterpreted or disregarded. There is, for instance, a limit to the rate at which an operator can deal with information. Considerable attention must be given to the ability of the operator to assess the condition of the system rapidly, with a minimum number of errors. The designer has access to a wide variety of display instruments, including the increasingly prevalent application of computer technology, and must evaluate the effect of instrument design, positioning, grouping and complexity in order to arrive at the optimum design. Closely associated with the display of information are the control devices with which they correspond. Of particular impor-

tance is the fact that the vast majority of operators will associate, for instance, the clockwise rotation of a control with the upward movement of a vertical gauge or the clockwise movement of a circular gauge. Such stereotyping appears to be universal, or at least very common. The failure to consider these factors during design can result in confusion and errors, particularly when the operator is under stress and will tend to respond with stereotypical action even though he has been trained otherwise.

The layout of the displays, controls and equipment in the system is often primarily determined by engineering requirements, with little consideration to the needs of the operator. Man, being an adaptable creature, can often accommodate poorly designed or positioned equipment under routine conditions, but the effect on performance in emergencies can be serious, thus increasing the probability of errors and accidents. A suitable layout can be achieved only if the designer takes into account the nature of the tasks involved, the manner in which they will be performed and the ergonomic considerations which govern the operator's abilities. These factors are addressed under the generic term "operability"; the goal of the designer should be to ensure that no feature inherent in the design will inhibit or preclude the safe operation of the system in any credible combinations of routine or emergency circumstances.

Many systems are subject to rapid changes which may require immediate response. If such changes are rare, the operator's response time may be degraded by the monotony of long periods of vigilance between sporadic periods of activity. The designer may choose to employ alarms in such systems in order to ensure that the operator is alerted to failures, or to abnormal conditions which may lead to failures. The alarm system should be independent of the monitoring system so that a failure in one will not affect the other. An alarm system will usually provide a distinctive visual and audible signal to alert the operator and provide a facility for testing the alarm circuit during normal operations. Although some means of acknowledging and silencing the alarm will be installed, any new alarm condition should immediately trigger the system again. A failure in the alarm system itself should trigger the alarm (i.e. fail-safe design). Where an abnormal condition that cannot be immediately counteracted by manual intervention may occur, the alarm system may be combined with a safety system which automatically takes action to limit the consequences of the fault.

An important factor related to safe operation of critical systems is the need for inspection and maintenance programs to maintain the system at the lowest probability of failure. Preventive maintenance schedules should be developed and modified as necessary during operations to ensure their effectiveness. Equipment should be positioned to provide ease of access for personnel and testing equipment; additionally, complex circuitry and mechanical components should be laid out and clearly labelled to facilitate fault-finding and the replacement of defective elements. All these principles serve not only to improve the effectiveness of inspection and maintenance procedures but also to encourage those responsible to carry out the prescribed procedures in a routine manner. This aspect is particularly important for back-up and emergency systems which, although not employed during normal operations, must be available at any time to support the system in the event of failure. There is a tendency for inspection and maintenance programs to be ignored if significant difficulty is involved in their implementation or if the reason for the program is not apparent or clearly stated; as a result, technical staff may be unfamiliar with the system when repairs are required, which may lead to unnecessary and potentially dangerous delays in restoring its function.

The loss of the *Ocean Ranger* and many other major accidents in high-risk systems illustrate that accidents are rarely caused by simple, individual equipment faults or human mistakes; rather, even in systems of balanced design, major accidents will depend on a complex chain of events including equipment faults, latent risk, and human errors. Any study of critical systems will of necessity involve the assessment of the hardware, materials, personnel and operating procedures which make up the systems. Failures in hardware and materials can be dealt with in a relatively objective manner using statistical data on equipment failures. The question of the reliability of the human operator, working under a prescribed set of procedures, involves a much higher level of subjective input; nevertheless, great value can be obtained by subjecting the human factors which influence the system to methodical analysis. Even if the analysis cannot produce a precise numerical result, the process itself will tend to expose areas where significant reductions in risk levels may be obtained.

All critical MODU systems should be subject to a level of analysis consistent with their potential impact on safety. Analysis and improvement of these critical systems will be the most cost-effective means of achieving an increased level of overall safety.

ITEM C-4

STABILITY RULES FOR MODUS

TABLE C-4

A Comparison of Stability Rules for Mobile Offshore Drilling Units

CRITERIA	CERTIFYING AUTHORITY			GOVERNMENT ORGANIZATION				
	American Bureau of Shipping (1980)	Det norske Veritas (1981)	Bureau Veritas (1975 Reissued 1982)	United Kingdom Department of Energy (Proposed 1984)	Norwegian Maritime Directorate (1982)	United States Coast Guard (1978)	Canadian Coast Guard (1984)	International Maritime Organization (1980)
Wind Heeling Moments								
Operational/Transit								
• Intact	36 m/s	36 m/s	"normal"	36 m/s	36 m/s	36 m/s	36 m/s	36 m/s
• Damaged	25.8 m/s	25.8 m/s	"normal" condition	25.8 m/s	25.8 m/s	25.8 m/s	25.8 m/s	25.8 m/s
Survival Draft								
• Intact	51.5 m/s	51.5 m/s	"extreme"	51.5 m/s	51.5 m/s	51.5 m/s	51.5 m/s	51.5 m/s
• Damaged	25.8 m/s	—	"normal" condition	25.8 m/s	—	25.8 m/s	25.8 m/s	—
Changing Draft								
• Intact	—	36 m/s	—	—	36 m/s	—	36 m/s	—
• Damaged	—	—	—	—	—	—	25.8 m/s	—
Time for Change (from operational to transit draft)	—	—	<3 hrs.	—	—	"min. time"	3 hrs.	"consistent with meteorological conditions"
Intact Stability (1)								
GM (surface vessels & jack-ups)	—	1.0 m	0.3 m	—	0.5 m	0.05 m	0.5 m	—
GM (column stabilized)	—	1.0 m	0.3 m	—	1.0 m	0.05 m	1.0 m	—
GM (temporary)	—	0.3 m	—	—	0.3 m	—	0.3 m	—
Energy Ratio (surface vessels & jack-ups)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Energy Ratio (column stabilized)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Maximum Wind Heel Equilibrium	—	15°	—	—	15°	—	15°	—
Minimum Wind Heel 2nd Intercept	—	30°	—	—	30°	—	30°	—
Method of determining Wind Heeling Moments	Standard calcs.	Standard calcs.	Special calcs.	Standard calcs.	Wind tunnel test req'd.	Standard calcs.	Standard calcs.	Standard calcs.

continued

TABLE C-4 (continued)
A Comparison of Stability Rules for Mobile Offshore Drilling Units

CRITERIA	CERTIFYING AUTHORITY			GOVERNMENT ORGANIZATION				
	American Bureau of Shipping (1980)	Det norske Veritas (1981)	Bureau Veritas (1975 Reissued 1982)	United Kingdom Department of Energy (Proposed 1984)	Norwegian Maritime Directorate (1982)	United States Coast Guard (1978)	Canadian Coast Guard (1984)	International Maritime Organization (1980)
Damage Stability (2)								
Maximum Heel Angle	—	15°	—	15°	15°	—	15°	—
Energy Ratio	—	1.0	—	1.0	1.0	—	1.0	—
Minimum Righting Moment	Wind heel	Wind heel at downflooding point	Wind "gust"	Wind heel	Wind heel at downflooding point	Wind heel	Wind heel at downflooding point	Wind heel
Waterline Damage Zone	Exposed outer portions	Exposed outer portions	—	Outer skin or periphery	Exposed parts	Outboard periphery	—	Exposed portions
• Condition for Application	Transit Operating Survival	Transit Operating —	Transit Operating —	Transit Operating —	Transit Operating —	Transit Operating Survival	Transit Operating —	Transit Operating —
• Penetration	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m
Vertical Extent								
• Surface vessels & jack-ups	Bottom upward without limit	Bottom to upper deck	Bottom to upper deck	Baseline upward without limit	Baseline upward without limit	Bottom to uppermost continuous deck	Baseline upward without limit	Baseline upward without limit
• Column Stabilized	—	3.0 m	2.3 m	3.0 m	3.0 m	—	3.0 m	3.0 m
Horizontal Extent								
• Surface vessels & jack-ups	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m
• Column Stabilized (3)	1/8	3.0 m	1/6	3.0 m	3.0 m	1/8	3.0 m	1/8
Damage Limitation (Column Stabilized)								
• Above waterline	1.5 m	5.0 m	5.0 m	5.0 m	5.0 m	1.5 m	1.5 m	1.5 m
• Below waterline	1.5 m	3.0 m	3.0 m	3.0 m	3.0 m	1.5 m	1.5 m	1.5 m
Flooding away from Waterline	—	(4) Any one Compartment	—	(5) Any one Compartment	(4) Any one Compartment	—	—	—
• Condition for application	— — —	Transit Operating —	— — —	Transit Operating Survival	Transit Operating —	— — —	— — —	— — —
Permeabilities								
• Tanks (4)/Voids/ Quarters	—	0.95	—	—	0.95	0.95	—	—
• Machinery spaces	—	0.85	—	—	0.85	0.85	—	—
• Storerooms	—	0.60	—	—	0.60	0.95	—	—

continued

TABLE C-4 (continued)

A Comparison of Stability Rules for Mobile Offshore Drilling Units

CRITERIA	CERTIFYING AUTHORITY			GOVERNMENT ORGANIZATION				
	American Bureau of Shipping (1980)	Det norske Veritas (1981)	Bureau Veritas (1975 Reissued 1982)	United Kingdom Department of Energy (Proposed 1984)	Norwegian Maritime Directorate (1982)	United States Coast Guard (1978)	Canadian Coast Guard (1984)	International Maritime Organization (1980)
Special Considerations								
Loss of Buoyancy	—	Whole column or portion thereof (6)	—	—	Whole column or significant part thereof(6)	—	—	—
Minimum Freeboard Downflooding (watertight)	—	0.6 m	—	—	—	—	—	—
Maximum Heel	—	35°	—	—	35°	—	—	—
Minimum Positive Domain	—	20°	—	—	20°	—	—	—
Minimum GZ	—	1.0 m	—	—	1.0 m	—	—	—

NOTES:

(1) In all cases except Bureau Veritas the areas under the righting and heeling moment curves used to determine the energy ratio are taken from the upright to the point of downflooding or the second intercept whichever is less. For Bureau Veritas, the same calculation is taken from the point of established wind equilibrium.

(2) In all cases except Bureau Veritas the domain of the energy ratio calculation is from the angle of static equilibrium after damage to the point of downflooding. For Bureau Veritas, the domain is taken from the angle of established wind equilibrium after damage.

(3) Fraction of column perimeter or length along periphery.

(4) Tanks normally pressed up need not be considered for any one compartment flooding.

(5) Tanks partially full need not be considered for any one compartment flooding.

(6) Portion thereof determined by regulatory body.

Source: *Industry Action on Stability of Mobile Offshore Drilling Units: A Status Report.* M.W. Praught, D.S. Hammett, J.E. Hampton, C.N. Springett. Presented at the Offshore Technology Conference, Houston, Texas, USA, May 1985.

ITEM C-5

ENVIRONMENTAL INFORMATION REQUIREMENTS

An extract from:

Suggested Activities for the Canadian Atlantic Storms Project
W.C. Thompson
Petro-Canada Resources
December, 1984

PRESENT OPERATING PROCEDURES

Prior to discussing operating procedures, it is important to distinguish between those related to exploration and those to production. Exploration consists of the collection of geophysical data and the drilling of wells both for exploratory and delineation purposes. Nearly all exploration is presently being conducted on either the Scotian Shelf or Grand Banks (Figure 1). Production consists of the removal of oil and/or gas from the reservoir and its subsequent delivery to a shore base. There are currently no production systems in operation on the East Coast though planning is well under way for such systems for both the Venture field near Sable Island and the Hibernia field on the Grand Banks.

An exploration program may proceed through three phases: planning, regulation, and operations, before it is completed. Each has a requirement for weather and other environmental information. The phases and environmentally dependent activities in each are shown in Table 1. Production proceeds through an additional phase, that of construction. The environmentally dependent activities related to production are shown in Table 2.

Nearly all exploratory drilling on the Grand Banks has been conducted by semisubmersible drilling units either of the anchored or dynamically positioned variety. Drilling in the deeper waters of the Scotian Shelf has been carried out mostly with semisubmersible units while in the shallower waters near Sable Island several wells have been drilled with jack-up units. Except for the brief period while in transit between wells, the jack-up units are less affected by weather than are the semisubmersible units.

TABLE 1
Environmentally Dependent Activities Related to Offshore Exploration

PHASE	ACTIVITY
Planning	Contingency plan Equipment selection Operations
Regulation	Impact statement Contingency plan Program application Well application
Operations	Data collection Prediction Ice management Emergency procedures Operations

Typically, an exploration well takes from three to six months to complete. During that time the drilling unit is attended to by at least one standby vessel. This vessel frequently alternates with another to provide supplies and during the ice season on the Grand Banks it may also participate in the ice management program. Crews are exchanged by helicopters. On the Grand Banks both the helicopters and supply vessels operate out of St. John's; on the Scotian Shelf helicopters generally operate out of Halifax and supply vessels either out of the Halifax or Canso areas depending on the operator.

TABLE 2
Environmentally Dependent Activities Related to Offshore Production

PHASE	ACTIVITY
Planning	Contingency plan Equipment selection Operating procedure Specifications Design criteria Operating criteria
Regulation	Impact statement Contingency plan Development plan Certification
Construction	Environmental prediction Emergency planning Operations Data collection
Operations	Environmental prediction Emergency procedures Operating procedures Data collection

All offshore drilling units in Canada operate under regulations prepared and administered by the Canada Oil and Gas Lands Administration (COGLA). The regulations require that:

- Qualified environmental monitoring personnel be placed on board each unit, and that they take and report synoptic meteorological observations on a continuous basis, aviation observations during daylight hours, and record currents at regular intervals.
- An adequate number of environmental sensors of specified quality be maintained on board and in suitable operating condition.
- A joint ice monitoring and management system be in place on the Grand Banks.
- Site-specific weather and sea-state forecast services be provided for each unit.

Further regulations relating to air safety are specified by Transport Canada and require that Instrument Flight Rules (IFR) planning procedures between shore bases and units be followed. These require the issuance and use of aviation forecasts.

Environmental data collection and management services are contracted to consulting firms. These firms hire the monitoring personnel. Observed data leave the units in two ways: by radio to marine base and then

to an Atmospheric Environment Service (AES) outlet for forecast purposes; and on logs at irregular intervals where the data are abstracted by the consultant and placed on magnetic tape for climatological purposes. The original logs are also forwarded to the AES where the data are placed on magnetic tape, subjected to quality assurance procedures and placed in the national archive. At monthly intervals, summaries of the climatological conditions are prepared and on completion of the well these, with the magnetic tape copies of the data, are provided to COGLA.

Weather and sea-state forecasts are also prepared by a consultant who need not necessarily be the same consultant that provides monitoring services. Site-specific forecasts are prepared by qualified meteorologists, issued twice daily and are valid for 48 hours with a longer range outlook. All consulting firms use guidance material comparable in quality to that available in AES offices. Sea-state forecasts are prepared by a variety of means. Most consultants use Canadian Forces Meteorological and Oceanographic Centre (METOC) charts and U.S. Navy Spectral Ocean Wave Model output as guidance, and then tailor these to local needs using Bretschneider or similar techniques. A recent innovation has been the introduction of operational spectral wave model output from a U.S. firm. Both weather and sea-state forecasts are verified on a regular basis.

Since there are yet no production systems in operation, it is not possible to outline their monitoring and forecasting programs. However, the basic modes of operation and supply will be little different from those of exploration and it is therefore expected that procedures will not be significantly different. It is important to note that much of the planning phase has been completed and in that phase significant use has been made of ship synoptic meteorological observations, hindcasting techniques, and the base of environmental data collected by drilling units since about 1980.

WEATHER NEEDS

Let us now try to identify those parts of an offshore operation which are weather sensitive and which would benefit from better quality information. This is not a simple task; a variety of opinions exist, but let me try to convey the views which I have observed from my contacts with those who work in the offshore.

An examination of Tables 1 and 2 will reveal that most of the activities relate to either compilation and analysis of existing data or prediction. The single greatest need in the analysis area is for a set of guidelines which provide extreme values of wind speeds for use in the offshore areas particularly for production design. Several estimates currently exist but are not in agreement. They need to be reviewed and new values computed which are acceptable to the operators, regulatory bodies, and to the AES.

Most of the needs are for prediction and I will now focus on them. Prediction serves two purposes; one is to enhance safety, the other is to increase operational efficiency.

There are three areas in an offshore program which are often cited as being of concern from a safety point of view. These are the helicopter operations, the supply vessels, and the drilling units themselves. The weather conditions that most significantly affect helicopter operations are low ceilings, poor visibilities, and in-cloud icing. Highly trained pilots and the use of sophisticated navigation equipment permit landings and takeoffs from drilling units in conditions to as low as 150 feet and one-half mile. Still these limits can be exceeded 50 percent or more of the time on some parts of the Grand Banks in July. The forecast of in-cloud icing or even the risk of it prevents a pilot from attempting a flight and it is therefore important that such forecasts be accurate; in particular the term "risk of" should not be overused.

The supply and other support vessels are subject to ice accretion from spray. This not only makes them top heavy but encases lifeboats reducing the ability of the crew to escape. The incidence of icing due to sea spray is highest closer to the coasts where temperatures tend to be colder.

Concern is often expressed about the ability of drilling units to survive winter storms on the East Coast. In order to be insured, all units must be certified by classification societies. Certification requires evidence that the unit has been designed to withstand a combination of 100-year return period winds, waves, and currents, each calculated in the world's worst operating areas. Additional safety can be obtained through ballasting and optimizing the ship's heading.

Safety is and will continue to be a rationale for issuing and improving the quality of weather forecasts. However, at this point in the development of Canada's offshore oil and gas industry, the greatest gains in terms of safety will not come from better forecasts but from increasing the knowledge of offshore operating personnel about the effects of weather on their activities, designing operating procedures to account for weather, and by using better methods of presenting forecast products. Basic concepts such as those illustrated in Figure 2 are not yet well understood by many working in the offshore.

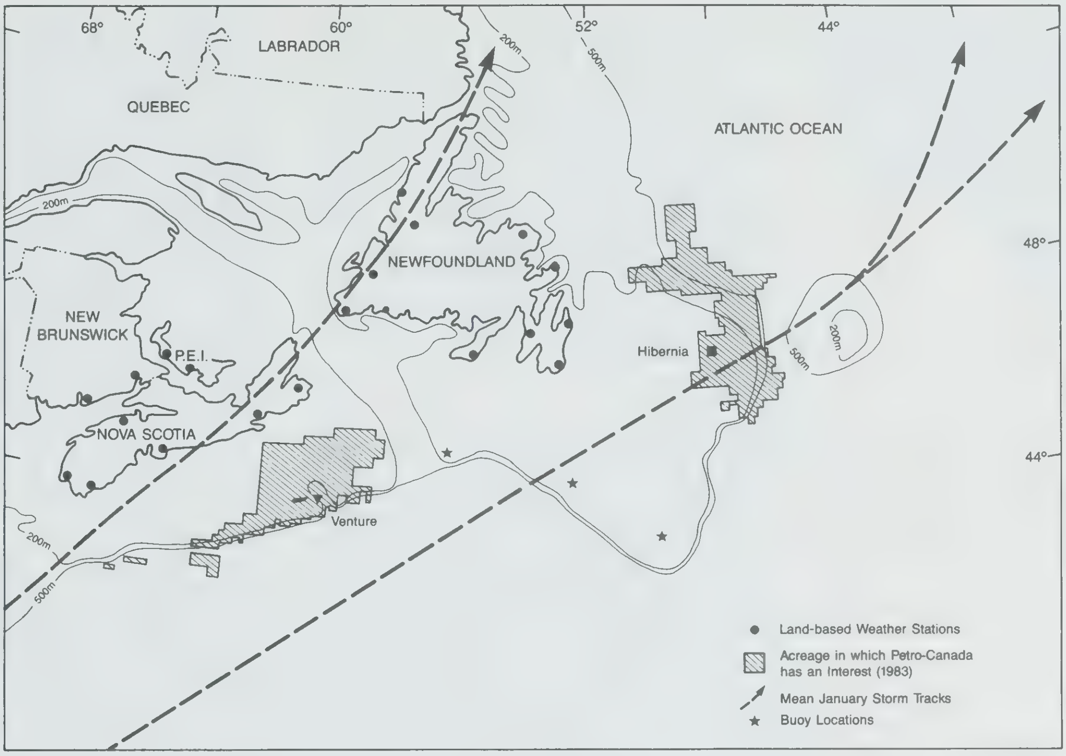

FIGURE 1 Major exploration and production areas on the East Coast of Canada.

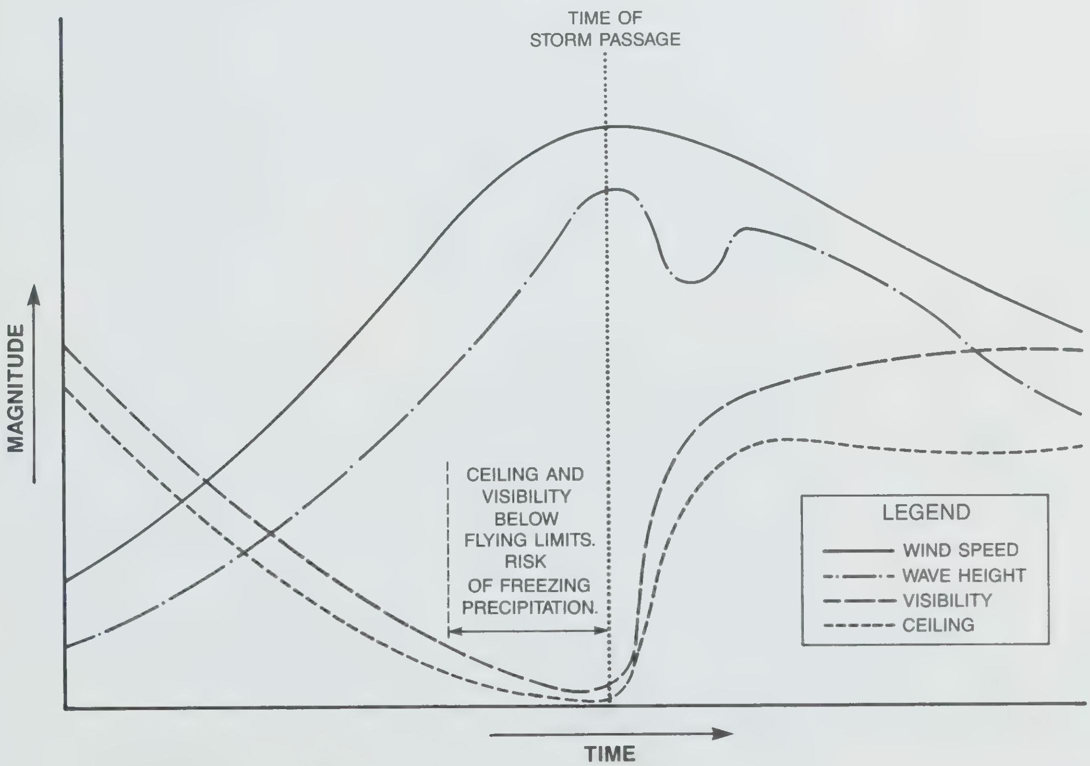

FIGURE 2 Schematic illustration of change in weather and sea-state conditions during a storm passage.

From my perspective, the greatest need for improved forecast quality, and the one which is likely to gain greatest acceptance, is to increase operational efficiency. Typical daily operational costs to support a drilling unit fall in the 200 to 400 thousand dollar range. Any gains demonstrated in reducing downtime represent a cost saving and will be looked on favourably by most operators.

Four environmental parameters affect the drilling unit and contribute to downtime. These are currents, ice, waves, and winds. They are *not* unrelated.

Currents

The oceans are governed by the equations of motion which result in a general circulation just as we observe in the atmosphere. There are local variations superimposed on this circulation, some by tides and others in the surface layer by winds. From monitoring programs such as those using drifting buoys we know that the currents are strongest near the shelf edges and weakest on the shelves as illustrated in Figure 3. Strong subsurface currents make well-head connections difficult and currents near the surface exert a lateral force on the drilling unit.

Ice

The currents are also a factor contributing to ice movement in the form of pack ice and icebergs. The northeast Grand Banks are subject to encroaching pack ice in early spring and icebergs at other times of the year but mostly in summer. Drilling units are not reinforced and are protected by ice detection and management systems. When a risk of collision exists, the unit severs its connection with the well and moves off location until the risk has subsided.

Waves

Apart from ice, the major cause of downtime on floating units is vessel motion, primarily heave. Several operations are conducted in completing a well, and each can only be performed within specified heave limits. For example, drilling on some vessels can be permitted until heave values of three metres are reached. At that time drilling must be suspended though the vessel can still remain connected until somewhat higher heave values are reached. If a reconnection is necessary, it cannot be made until the heave levels subside to one metre. Each drilling unit has associated with it a response amplitude operator function such as those shown in Figure 4 which relate vessel heave to wave height. Using this function and a wave spectrum like that shown in Figure 5, one can calculate the heave spectrum of the unit as illustrated in Figure 6. Forecasts of heave derived from a predicted wave spectrum are particularly useful for planning day-to-day operations.

Such calculations are also useful in the planning phase for selecting equipment and estimating drilling costs when a continuous wave record is available. To illustrate, Figure 7 shows the calculated heave estimates derived from Waverider records on the Grand Banks during 1980 for a typical semi-submersible drilling unit. The drilling and reconnect limits are superimposed. This type of information tells the planner that drilling would have been suspended twice and that the vessel may have to stand by several hours particularly in winter if a reconnection is necessary.

Wind

Wind does not directly cause downtime on the unit even though high speeds can create large lateral forces as shown in Figure 8. More significantly, it generates waves, and contributes to ice movement and the formation of currents which do create downtime. Waves are generated by winds from local storms and from storms which may be hundreds of miles away as illustrated in Figure 9. Accurate predictions of wind over an ocean basin allow the wave spectrum and hence vessel heave to be predicted. The techniques for predicting ice movement are not yet so well developed.

From the point of view of the regional exploration manager and those responsible for the day-to-day operation of the individual drilling units, it is important to know whether supply vessels can load or unload and whether the helicopters can make crew changes, but it is equally if not more important to know what lateral forces will be imposed on the unit, how much heave the unit will experience and whether ice will force the unit off location. This information cannot be derived solely from the weather forecast; it requires a knowledge of how the meteorological and oceanographic factors will interact. Offshore operating personnel frequently do not have sufficient knowledge to anticipate the end result of these interactions.

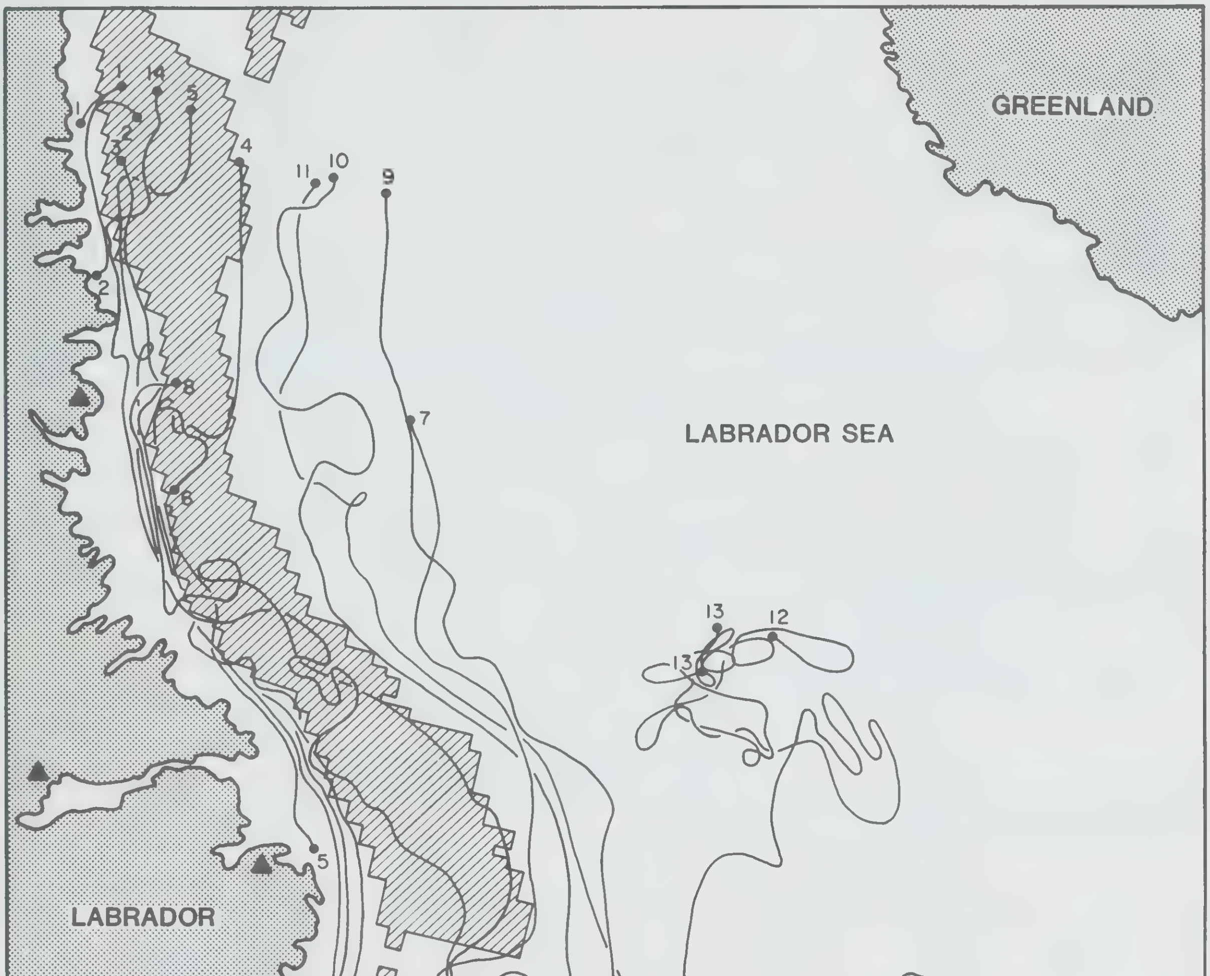

FIGURE 3 Trajectories of 14 Argos tracked buoys released in the Labrador Sea, 1981-83.

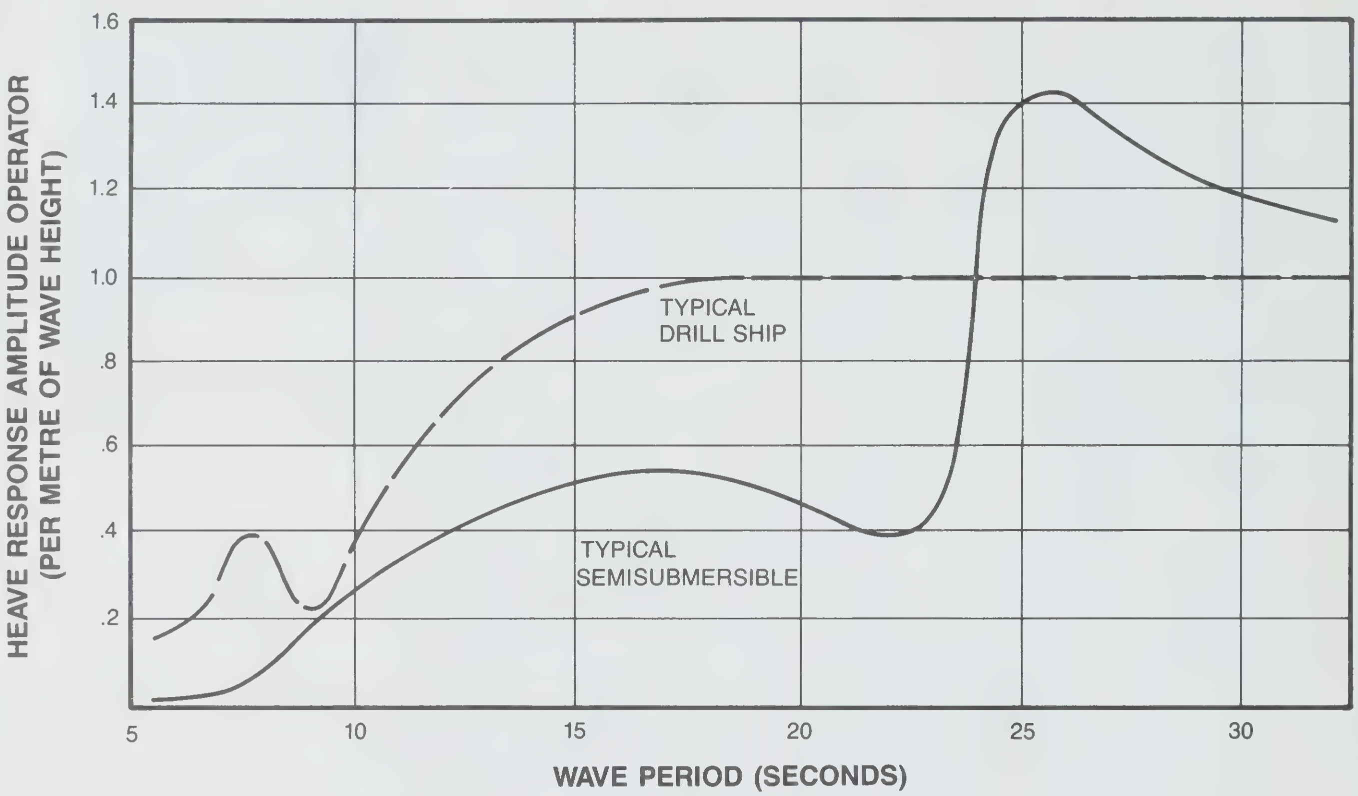

FIGURE 4 Heave response comparison for a typical drill ship and semisubmersible in head seas (drilling draft).

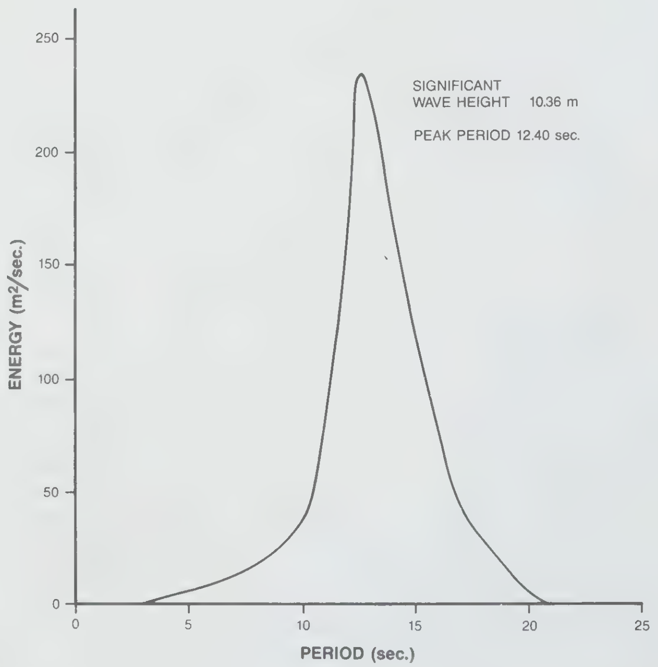

FIGURE 5 Wave spectrum – 0859 NST, February 15, 1982 Hibernia location.

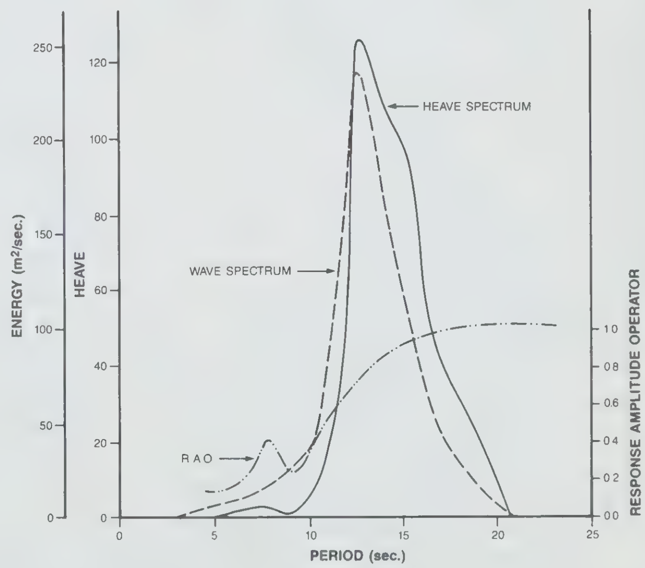

FIGURE 6 Heave spectrum for a typical drill ship.

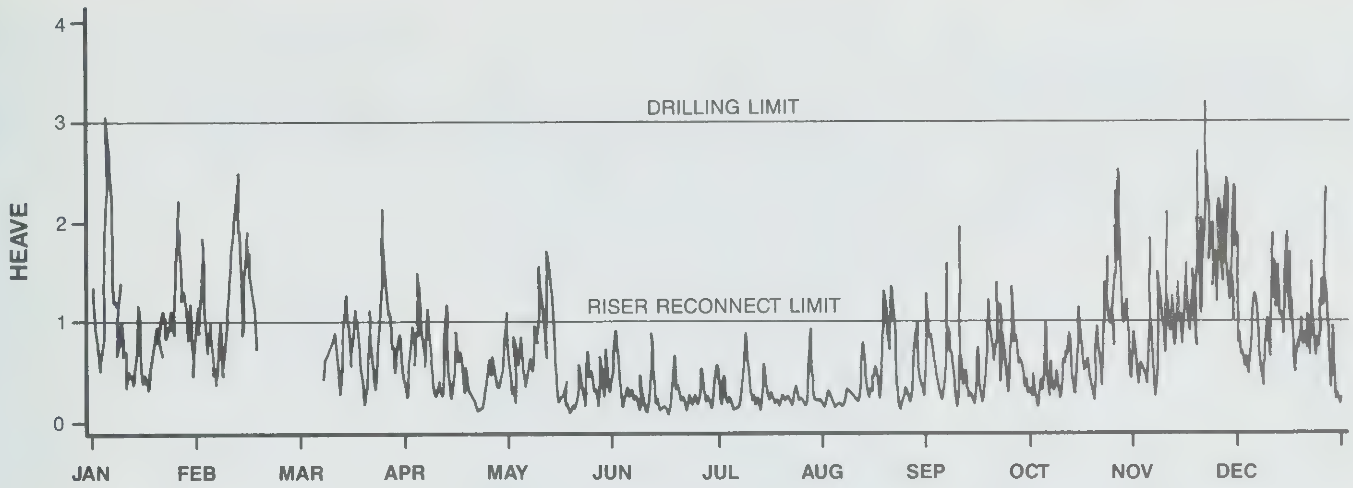

FIGURE 7 Calculated heave response for a typical semisubmersible – Northeast Grand Banks 1980. (Prepared By J.R. Buckley)

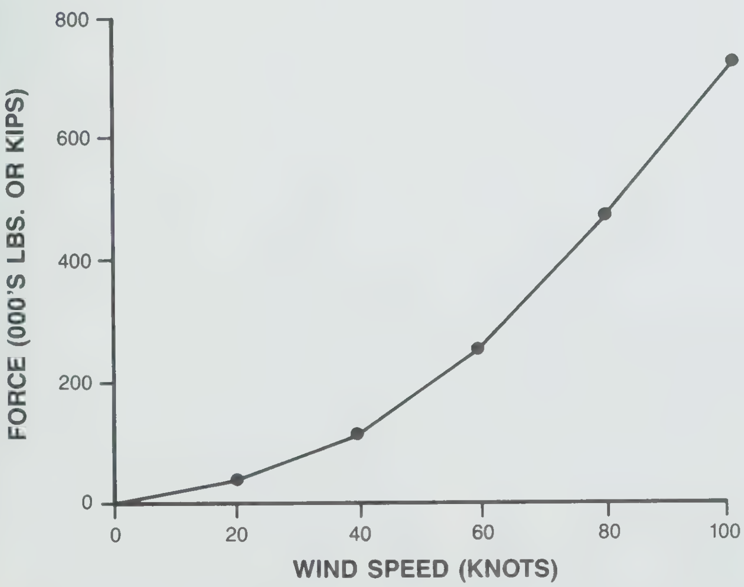

FIGURE 8 Worst case wind forces on a typical semisubmersible at drilling draft.

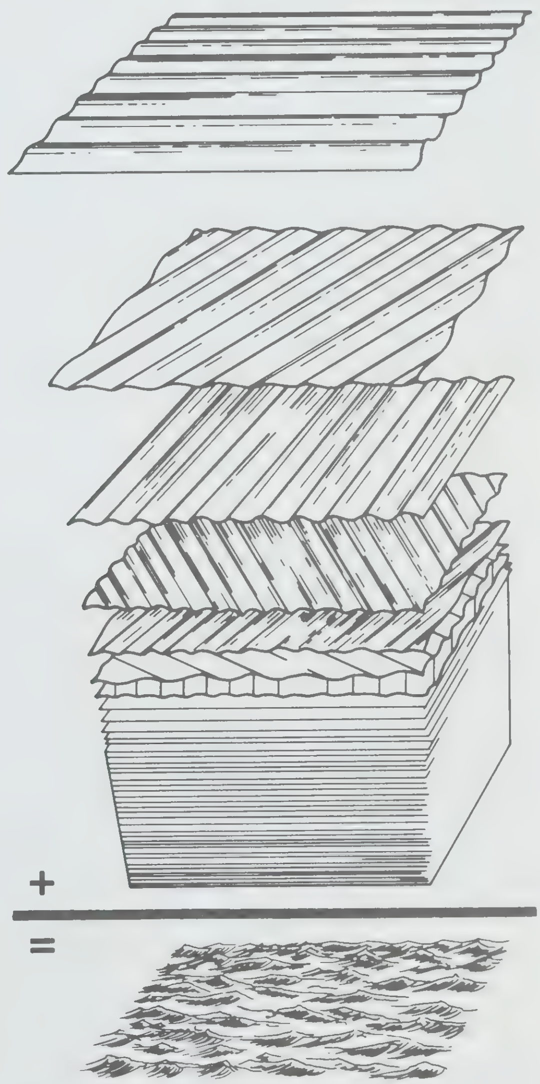

FIGURE 9 A sea is generated by winds in many different areas.

ITEM C-6

SUGGESTIONS FOR RESEARCH AND DEVELOPMENT

Recommendations for Research and Development Related to Safety Offshore Eastern Canada
November, 1984

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IMPROVED SAFETY CRITERIA

Improved safety criteria for the design and operation of offshore structures are required. Better methods for predicting behaviour in potentially adverse circumstances can be achieved through improvements in physical and mathematical models validated and supported by full- and model-scale experiments.

Behaviour of Offshore Structures

Systematic measurements are required of the full-scale, dynamic behaviour of offshore structures under the environmental loads of wind, waves, currents and ice. Such measurements are difficult and expensive to obtain but they are necessary for the verification of both physical and numerical simulation studies as well as the direct inclusion in design calculations. At present most full-scale measurements are the property of private companies, and model testing laboratories do not have access to these data. Measurements of full-scale, dynamic behaviour must be complemented by comprehensive measurements of environmental conditions.

Modelling Improvements

There is a need to improve the techniques of both physical and numerical modelling of intact and damaged offshore structures. Problems concern definition of the necessary and sufficient requirements for detailed descriptions of wind, wave, current, and ice conditions and the accurate simulation of these factors. NRC is presently developing segmented wave generators in a model test basin for the simulation of realistic multi-directional sea states. This new facility will provide in Canada one of the world's most advanced facilities for simulating wave action on structures. The development of physical facilities must be accompanied by improved full-scale data. Another NRC project now in the definition phase will involve the conversion of existing facilities for studies of simulation techniques for the application of dynamic wind loading on floating offshore structures, and interactions between waves, currents, and structures. These projects will help to determine what environmental modelling is necessary and sufficient to satisfy the requirements for designing safe offshore structures.

Ocean Ranger Model Test Data

A large amount of model test data collected during the *Ocean Ranger* investigation was determined to be not directly related to the specific disaster, and is not yet analysed. These data can be used to validate new methods and subsequent development of safety criteria. The data from tests in wind and waves, for example, may well assist in improving the behaviour in normal operation, as well as in extreme conditions.

ENVIRONMENTAL MONITORING

Improved monitoring procedures of environmental factors are necessary for input to the design of offshore structures. Not only are more measurements of environmental conditions of waves, wind, currents and ice required, but a complete re-evaluation is necessary of the usefulness of existing data and the adequacy of measurement instrumentation. In addition it will be necessary to measure parameters which have been neglected in the past, such as the directional spreading of wave energy, interactions of waves and currents, wind velocity profiles over seas, etc. Better environmental data are essential before it is possible to improve physical and numerical modelling techniques, which are essential tools for design of offshore structures.

ICING OF OFFSHORE STRUCTURES

The forecasting of icing severity on vessels and offshore structures is seriously hampered by the lack of reliable observational data on which statistical correlations can be based and by which numerical models can be developed and/or verified. Model development is also hampered because, amongst other things, little knowledge exists of the water flux and drop size spectrum over the ocean and how it is modified by the presence of a structure or vessel, nor is it known how ice nucleation or the subsequent icing process is affected by the salts in saline water. Amongst topics also requiring research is the effect of the complex geometry of many of the structures on droplet impingement and heat transfer patterns, and, together with gravity and the air flow field, on the water run-back and run-off processes. The Low Temperature Laboratory of DME/NRC has been involved in icing research for upwards of 30 years, first in aircraft and helicopter icing, and more recently in the atmospheric icing of structures and in the icing by sea spray of fishing vessels. Although present commitments limit the NRC contribution, the facilities and expertise of this Laboratory could be a significant contribution to a co-ordinated national commitment to research in this field.

ICEBERG RESEARCH

Eastern Canadian operation of exploration or production platforms and support vessels faces a hazard encountered in very few other regions of the world – icebergs. Research into several aspects of iceberg behaviour is required if safe oil and gas production is to be achieved over the length of Canada's East Coast. Improved prediction methods for iceberg trajectories are required, the effect of scouring on the ocean floor must be further defined, methods and regulations for safe towing of icebergs must be refined and the impact forces between icebergs and different types of structures (pipelines, fixed platforms, artificial islands) must become predictable and reliable. A number of Canadian organizations on the East Coast are already addressing many of these issues. Research groups such as C-CORE (Centre for Cold Ocean Resources Engineering, Memorial University of Newfoundland), Arctec Canada Limited, and NORDCO (Newfoundland Oceans Research and Development Corporation) have developed a considerable knowledge and experience related to iceberg properties and behaviour. Within NRC, the Division of Building Research has studied real ice mechanics for some years. Closely working with the Division of Building Research, the Division of Mechanical Engineering has been active in developing modelling techniques for ice/structure interactions. The new NRC Centre for Cold Regions Research, working with the Centre for Frontier Engineering Research, in Edmonton, will study the behaviour of structural components at low temperatures. The ice facilities in the Institute for Marine Dynamics and in the Division of Mechanical Engineering may be used for the modelling of iceberg impacts.

SIMULATION OF CONTROL SYSTEMS

By the standards of many advanced applications, the ballast control system on the *Ocean Ranger* was very primitive. In the nuclear and in the aircraft industries, sophisticated, elaborate, but reliable control systems have been developed that ensure effective control in all imaginable situations. Numerical and physical simulators have been built that allow designers, builders, and operators to examine an extensive range of possible accidents and operational situations. Physical simulators also allow operators to be trained with safety and to learn to cope with hypothetical accidents to the vessel or its controls. Simulators have demonstrated a proven effectiveness with large ship designs. The value of such investments does not appear to have been realized in the design and operation of structures and vessels used in oil and gas exploration. The cost of effective simulators is high but has decreased with the decreasing cost of computer hardware. Canada has a world-wide reputation in the manufacture of aircraft and nuclear simulators. This experience should be applied to the offshore industry.

EVACUATION PROCEDURES

Semisubmersibles pose special problems in efforts to safely evacuate the crew in times of danger or a storm. With large numbers of crew that do not have an extensive marine background, the procedures must be similar to those on a passenger vessel, with the additional complication caused by the unusual configuration and the stability characteristics of the semisubmersible. Safe evacuation methods must include proper apparel, escape vessels, and launching and recovery procedures in all foreseeable weather conditions. Much needs to be done and novel approaches should not be discouraged. In recent months some attention in other countries has been given to methods of evacuation from semisubmersibles that can be controlled from supply vessels. This is a reasoned approach but further research and development is necessary to reduce cost and increase the effectiveness in extreme conditions.

PROPERTIES OF MATERIALS

The Canadian offshore environment is unique in many aspects. This is the case, not only on the East Coast, but in the Beaufort Sea and in the high Arctic. Deep water, icebergs, high waves, severe storms, and ice fields, combined with extreme low temperatures provide a unique environment for operators of offshore facilities. In these special conditions, improved knowledge of material strengths, fatigue properties and corrosion behaviour will be essential if safe and economical structures are to be developed. NRC and the University of Alberta will be addressing some research aspects of these problems in the Cold Regions Research Institute and Centre for Frontier Engineering Research in Edmonton.

OFFSHORE COMMUNICATIONS

In recent years the increasing number and capability of satellite communications, coupled with the capacity for electronic information and data transfer could provide much more complete and continuous moni-

toring of equipment operating offshore in hazardous environments. Land-based centres, with operations and equipment experts, could monitor simultaneously a number of vessels. These could also be linked with iceberg forecasting and weather reports. Such equipment links could monitor critical control and equipment systems on vessels, independently of the site operators. Shore stations would be alerted if trouble developed and vessel operators could seek expert advice. Warnings of storm or iceberg hazards could be automatically transmitted in numerical or in graphical form for easy interpretation. A small example of the kind of communications that is technically feasible is the medical communication link that has been operated by the Centre for Offshore and Remote Medicine (Memorial University of Newfoundland) with one drilling rig during the past year or so.

REMOTELY CONTROLLED SUBMERSIBLES

Divers have been used for critical maintenance and repair operations on almost all offshore exploration and production facilities. Under the best conditions, diving for these applications is a hazardous occupation. In Hibernia and along the northeast Canadian coast, as well as in the Arctic, diving in support of offshore exploration and production will be especially hazardous because of the depth, the cold and other unfavourable environmental conditions. The development of advanced remotely controlled submersible vehicles, with intelligent controls and sensors and robot manipulators, could contribute to greatly increased reliability and the saving of many lives. Canadian industry is a world leader in remotely controlled submersible vehicles. The requirements for East Coast offshore equipment provide an opportunity for Canada to maintain its established leadership if research and development for such applications is encouraged. The NRC has recently sponsored studies of Canadian needs and capabilities to define priorities for further Canadian R & D in this area. Through consultation with other government departments, industry and foreign collaboration, a co-ordinated program will be prepared for research and development of advanced remotely controlled submersible vehicles.

EMERGENCIES

APPENDIX D

APPENDIX D

EMERGENCIES

ITEM D-1

SUMMARY OF SIGNIFICANT INCIDENTS

Offshore exploration activities are affected by a variety of unplanned events which pose a potential threat to the safety of MODUs, to those employed on them and to the vessels and helicopters which support an exploration program. For eastern Canadian exploration activities there is, however, no complete record of such events.

To illustrate the type and frequency of incidents which have affected offshore operations since 1980 the following summary of incidents was prepared. Given the lack of appropriate documentation and reporting procedures, the summary is selective in the events listed and is not intended to be exhaustive.

Vessel Collision February 21, 1980	The supply vessel, *Ravensturm*, was discharging bulk material on the windward side of the semisubmersible, *SEDCO 706*, at Hibernia B-08. Due to a rapid change in weather, the vessel collided with the rig, snapping three of the rig's fender timbers and denting a shell plate on starboard column two.
Vessel Collision May 16, 1980	The supply vessel, *Kreuzturm*, was offloading fuel and water on to the *SEDCO 706* at Hibernia B-08. The vessel lost power and struck starboard column two, damaging three fender timbers and denting the shell plate.
Loss of Life September 8, 1980	The supply vessel, *Neutor*, was working at sea in heavy weather. A crewman, while working on the deck, was washed overboard and perished.
Vessel Collision April 6, 1981	The supply vessel, *Balder Hudson*, struck the south-facing leg of the jack-up, *Rowan Juneau*, at Venture B-13 holing the port bow of the supply vessel.
Loss of Vessel July 3, 1981	The *Arctic Explorer*, a seismic research vessel, sank off Cape Bauld, apparently due to a list and subsequent downflooding. Thirteen persons perished, while nineteen persons were rescued.
Vessel Collision October 2, 1981	The supply vessel, *Kreuzturm*, while performing a loading operation, struck starboard column three of the *SEDCO 706* at Nautilus C-92, snapping three fender timbers and denting the column shell plate.
Evacuation November 26, 1981	The *Euro Princess*, a grain carrier, drifted towards the jack-up, *Rowan Juneau*, at Venture B-43. Forty-four members of the drilling unit were evacuated by helicopter the next day, as the carrier drifted within one-half mile of the rig. A skeleton crew of 18 remained on board.
Unintentional List February 6, 1982	The *Ocean Ranger*, a semisubmersible, at Hibernia J-34 developed a port heel of 6 degrees requiring all crew to report to lifeboat stations. The list was corrected.
Loss of Rig February 15, 1982	The *Ocean Ranger* at Hibernia J-34 developed a severe list. The crew evacuated the rig, rescue attempts were unsuccessful and all 84 perished.

Mooring System Failure March 5, 1982	The jack-up, *Zapata Scotian*, located in Halifax Harbour broke loose from its moorings and drifted towards a suspension bridge. The rig was eventually brought under tow and no damage resulted.
Vessel Collision July 11, 1982	The supply vessel, *Schnoorturm*, was in the process of picking up passengers from the semisubmersible, *Zapata Ugland,* when it lost power. Due to the design of the restarting system the vessel was placed in reverse. The vessel's stern struck the rig's starboard centre column and diagonal-aft bracing, denting both components and requiring shipyard repairs.
Diving Accident July 16, 1982	The drill ship, *Pelerin*, was at Pothurst P-19 on the Labrador Shelf when a manned observation bell fell in 646 feet of water. The supply vessel, *Balder Cabot*, and a MANTIS submersible recovered the observation bell and its two occupants the next day.
Vessel Collision August 18, 1982	The supply vessel, *Wimpey Seahunter*, drifted back onto the centre column and pierced the column shell plate of the semisubmersible, *Vinland*, at West Esperanto B-78. The rig was repaired at sea.
Serious Injury August 24, 1982	Two welders were severely burned on the *SEDCO 706* at Linnet E-63 when they were doused with helicopter fuel that ignited.
Evacuation September 17-18, 1982	A hurricane was forecast to approach the drilling area on the Grand Banks. All 86 crew members of the *SEDCO 706* and 38 from the *Zapata Ugland* were evacuated by helicopters and a supply vessel as a precautionary measure.
Vessel Collision September 17, 1982	The supply vessel, *Seaforth Jarl*, slipped its mooring and struck the south-facing leg of the jack-up, *Zapata Scotian,* at Olympia A-12.
Vessel Collision October 15, 1982	The supply vessel, *Balder Borkum*, was alongside the semisubmersible, *SEDCO 709,* at Shubenacadie H-100 with the fuel hose connected. A hydraulic pipe on the supply vessel broke, causing the propeller to reverse pitch. The vessel's starboard side hit starboard column three of the rig and snapped four fender timbers.
Vessel Collision December 1, 1982	The supply vessel, *Nordertor*, was discharging cargo on to the semisubmersible, *SEDCO 706,* at North Dana I-43 when it lost power to its bow thruster and struck the rig's starboard column three, breaking three fender timbers and denting the shell plate.

Vessel Collision December 27, 1982	The supply vessel, *Balder Husum*, struck starboard column three of the *SEDCO 709* at Shubenacadie H-100 Atlantic Deep. Four fender timbers were broken and the shell plate dented.
Ice Collision Threat December 28-29, 1982	The *SEDCO 706* at North Dana I-43 evacuated 34 non-essential personnel by helicopter and pulled its anchors as a 250,000-tonne iceberg came to within 5.3 nmi of the rig.
Ice Collision Threat February 16-18, 1983	The *SEDCO 706* was drilling at North Dana I-43 and the semisubmersible, *West Venture,* at Hibernia I-46. A winter storm and drifting ice moved close to the drilling area. The *SEDCO 706* was towed to Marystown. The *West Venture* could not be brought under tow due to 80-knot winds and 60-foot seas and rode out the storm at anchor.
Ice Collision Threat March 11, 1983	The *SEDCO 706* at North Dana I-43 and the *West Venture* at Hibernia I-46 pulled anchors due to encroaching ice.
Vessel Collision April 24, 1983	The supply vessel, *Balder Borkum*, was on close standby to the *SEDCO 709* at Glenelg J-48. Due to a computer malfunction, control was lost and the vessel struck the rig's anchor chain and starboard column four.
Loss of Life June 20, 1983	At the site of the sunken *Ocean Ranger* divers were working in 33 metres of water installing brackets on the starboard pontoon. An underwater explosion killed two of the divers.
Loss of Life June 26, 1983	At the site of the sunken *Ocean Ranger* two divers were working in about 42 metres of water on the underside of the starboard pontoon, attempting to re-install a manhole cover. A valve on top of a make-shift buoyancy drum opened causing loss of buoyancy. The drum and cover caught in a diver's umbilical dragging him to the 66-metre level. The diver perished by drowning.
Vessel Collision August 14, 1983	The supply vessel, *Stad Minerva*, was in the process of turning while departing the semisubmersible, *John Shaw,* at Bluenose G-47 when its power failed, causing loss of control of the vessel. The vessel struck port columns one and two. The shell plating on both columns was dented and required shipyard repair.
Vessel Collision September 3, 1983	The supply vessel, *Seaforth Commander*, was moored at the *Vinland* at Uniacke G-72. The supply vessel was discharging bulk material when weather and seas caused it to impact with the centre starboard column of the rig denting the shell plating.

Vessel Collision October 21, 1983	The supply vessel, *Seaforth Jarl*, was backing into the *SEDCO 706* at North Dana I-43 to discharge cargo. Weather and sea conditions caused the vessel to impact with port column three breaking three fender timbers and denting the column shell plating.
Mooring System Failure November 28, 1983	The semisubmersible, *SEDCO 710*, at Terra Nova K-08 was hanging-off due to weather conditions when an anchor chain snapped.
Loss of Vessel December 18, 1983	The supply vessel, *Seaforth Jarl*, was transporting anchor chain from Halifax to the *SEDCO 710* at South Hibernia K-02. The anchor chain was not secured to deck eyeplates and the chain shifted causing the vessel to sink. Eleven crew members evacuated in one life raft and were rescued shortly after.
Evacuation December 21-27, 1983	The *SEDCO 706*, *West Venture*, and *John Shaw* operating on the Grand Banks suspended all operations due to storm and freezing spray warnings. Helicopters and supply vessels evacuated crews from the rigs. Approximately 20 maintenance and marine workers were left on each rig.
Vessel Collision January 5, 1984	The supply vessel, *Kreuzturm*, was moored and offloading at the *West Venture* at Hibernia K-14. The mooring rope caught in the vessel's propeller resulting in power outage and loss of control. The anchor chain was driven against column four causing two dents.
Vessel Collision January 8, 1984	The supply vessel, *Balder Borkum*, was backing into position to offload at the jack-up, *Glomar Labrador I*, at Louisburg T-47. An electrical generator failure reversed the pitch of the propeller. The stern of the vessel went under the starboard side of the rig damaging the supply vessel's radar antenna.
Vessel Collision January 26, 1984	The *SEDCO 710* was offloading when the crane support collapsed. Damage occurred to both the crane and the supply vessel *Wimpey Seatiger* as part of the crane boom and a blowout preventer fell to the deck of the vessel.
Ice Collision Threat February 19, 1984	The semisubmersible, *John Shaw*, at Trave E-87 pulled anchors due to an encroaching ice field. The *SEDCO 706* at Archer K-19 also retreated south of the drill site. The *West Venture* at the Hibernia I-46 location continued drilling.

Loss of Well Control February 22, 1984	A blowout occurred on the semisubmersible, *Vinland,* at Uniacke G-72 due to human inaction and the successive failures of five control systems. Seventy-six crew members abandoned the rig in two lifeboats. The crew members transferred to the supply vessels, *Seaforth Commander* and the *Claymore Sea*, in the lee of Sable Island, then to the *Zapata Scotian* and then to shore via helicopter. One man died of natural causes en route to shore.
Ice Collision Threat March 10, 1984	The semisubmersible, *John Shaw*, at Trave E-87 was forced to pull anchors as the ice field approached the drill area.
Vessel Collision March 13, 1984	The supply vessel, *Heather Sea*, was involved in a collision with the semisubmersible, *Vinland*, at Uniacke G-72. The forward mast of the supply vessel was heavily damaged while no serious damage occurred to the rig.
Ice Collision Threat April 10, 1984	The *SEDCO 706* at Voyager T-18 was forced to move off location due to an encroaching ice field. The *SEDCO 710* was in the process of weighing anchors from its site at Terra Nova K-08. The *John Shaw* and *West Venture*, at South Mara C-13 and Hibernia C-96, were in the process of suspending drilling. All rigs left their drill sites as approximately 150 icebergs were sighted in the drilling area.
Ice Collision Threat May 10, 1984	The semisubmersibles, *SEDCO 710*, *SEDCO 706*, *West Venture*, and *John Shaw*, were forced off location due to encroaching icebergs. Seven icebergs were located in the drilling area but none was grounded or endangered any of the rigs.
Evacuation August 22, 1984	The *Zapata Scotian* was at Venture N-91 when a loss of circulation occurred. Twenty-one workers were evacuated to the supply vessel, *Balder Borkum*, via personnel baskets, as a precautionary measure; they were returned the following day. The remaining forty-four workers stayed on board.
Evacuation September 16, 1984	The jack-up, *Rowan Gorilla*, and the semisubmersible, *Bow Drill II,* were on location on the Scotian Shelf when hurricane Diana approached the drill area. Approximately 52 persons on the *Rowan Gorilla* and 16 of the 97 on the *Bow Drill II* were evacuated by helicopter.
Evacuation September 20, 1984	The *Zapata Scotian* at Venture N-91 developed a well control problem causing the evacuation of 55 of its crew by lifeboats. The crew was picked up by supply vessels and transferred to the *Rowan Juneau*. The 9 remaining crew members were evacuated by helicopter later that day.

Vessel Collision Threat
October 9, 1984

The *MV Montreaux*, a 500-foot, 48,000-tonne bulk carrier, travelling at 14 knots was sighted by the *SEDCO 706* at White Horse N-92 on its radar screen. The carrier was 6 nmi from the rig on a course inside the rig's anchor pattern, when it altered course coming within 4 nmi of the rig.

Evacuation
November 1, 1984

The jack-up, *Glomar Labrador I*, was north of Venture N-91 drilling a relief well at Venture B-92 when pressure problems occurred. Twenty-five crew members were evacuated by helicopter. Later an additional 19 crew members were taken off leaving a crew of 39 on board. All drilling was eventually suspended.

Ice Collision Threat
December 6, 1984

The *SEDCO 706*, *Bow Drill I*, and *Bow Drill III* were on location on the Grand Banks when a 500,000-tonne iceberg came within 9 nmi of the *Bow Drill III*. A total of 125 non-essential personnel were evacuated from the 3 rigs by helicopter. The *SEDCO 706* was towed 10 miles to the north of its drill site by 2 supply vessels. The iceberg was brought under tow by the supply vessel *Schnoorturm*.

Ice Collision Threat
February 2-3, 1985

Five semisubmersibles, the *Bow Drill I, II, III*, *Vinland*, and *John Shaw*, were towed away from sea ice. Most workers remained on the rigs as weather conditions did not permit evacuation.

Fire
March 10, 1985

The supply vessel, *Arctic Shiko*, was taken under tow for Halifax after an engine room fire occurred about 100 kilometres northeast of Sable Island.

Tow Line Failure
March 19, 1985

The *Bow Drill III* was under tow by supply vessels, *Trinity Bay* and *Chignecto Bay*, south of Cape Race when the rig's tow line broke. The rig was returning to the Grand Banks to resume drilling operations but was diverted to St. Mary's Bay after the incident.

Helicopter Accident
March 20, 1985

A Sikorsky S-61 helicopter departed the semisubmersible, *SEDCO 709*, on the Scotian Shelf, executing a crew transfer, when it developed mechanical problems and ditched approximately 10 kilometres from Musquodoboit Harbour. All 17 crew members were rescued from life rafts.

Evacuation
April 11, 1985

The *Bow Drill III* had just returned to the site of the North Ben Nevis P-03 wildcat well on the Grand Banks when the rig was forced off location by a 100,000-tonne iceberg. Forty-two of the rig's crew were evacuated by helicopter. Five crew members from the supply boats the *Chignecto Bay*, *Garbarus*, *Toanui*, and *Trinity Bay* were injured during attempts to pull the rig's eight anchors. One anchor did not release and was dragged as the rig was towed out of the iceberg's path. The iceberg passed within one-half nautical mile of the rig.

Loss of Life
April 11, 1985

Two crew members were working on the anchor chains of the *SEDCO 710* in Halifax Harbour in a two-man work basket supported by a crane. The work basket fell into the water and one of the workers died as a result of the fall.

ITEM D-2

ABANDONMENT AND IMMERSION SUITS

Ship/Rig Personnel Abandonment and Helicopter Crew/Passenger Immersion Suits: The Requirements in the North Atlantic
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Command Surgeon
Maritime Command
Halifax, Nova Scotia
December, 1984

[Editor's Note: This paper has been accepted for publication in 1985 in the Journal of Aviation, Space, and Environmental Medicine.*]*

GENERAL

The first basic principle of survival is protection from the environment. The two primary environmental threats to personnel working off the East Coast of Canada on board ship, oil rig or helicopter are hypothermia and drowning. The immersion suit is designed to provide protection from hypothermia through layers of trapped air which produce the necessary body insulation. This has a secondary benefit of providing some flotation, but a life preserver must also be used to ensure sufficient buoyancy and correct flotation angle in order to prevent drowning. Many authors have discussed the subject in the past and tested a variety of suits (References 1, 2, 11, 12, 16, 23-27, 29-35 37-44, 46, 48-50). The object of this report is to review the disappointing progress to date.

The suit should be comfortable, easy to don and doff, durable and simple to operate. It should possess a smooth, streamlined profile that does not impede escape or ability to perform lifesaving acts, such as boarding a life raft and operating a rescue beacon or flare. It should also look effective and smart to avoid reluctant and, perhaps, improper use, and, last but not least, it must not leak. Recent testing of the most promising suit after it was introduced into North Sea oil operations reconfirms there is still not a suit in the world that fulfills all the desirable qualities. General problem areas arise basically because of mutually compromising requirements.

There has been considerable debate for years as to whether a wet suit or dry suit principle should be used. Supporters of the wet suit quite correctly state that it is much cheaper and easier to make a comfortable wet suit because there is no requirement to fit waterproof neck seals, wrist seals, footlets, or zippers. However, one basic law of physics that cannot be overcome is that water conducts heat away from the body approximately 27 times faster than air. There is a place for the wet suit for some diving operations, where people are continuously monitored, the diving times are known, and hot showers are available on completion of the dive, but not for the survivor in the North Atlantic where prevention of heat loss is critical. The operators must wear a totally waterproof suit, as a leakage of only one litre of water into the suit will reduce the thermal insulation by at least 30 percent (3, 4, 22). Recent work suggests that this is on the conservative side and it is more likely to be 40 percent (5).

There is a dilemma, in that an impervious suit worn for more than just a few minutes causes heat stress and discomfort. The sweat cannot evaporate so it saturates the underwear and ultimately runs into the footlets. Ironically, this can promote hypothermia if the wearer is placed in the survival situation. It is noted that a considerable amount of research and development has been carried out to produce the ideal suit – one that will allow perspiration to evaporate through the material, yet be waterproof when totally immersed.

Due to the shortage of flax during the Second World War, a series of "Ventile" or air permeable fabrics was invented by Dr. Pierce at the Shirley Institute in the United Kingdom. Long-fibre Egyptian cotton was chosen as the basis of the fabric because when it was woven into the cloth, it developed its full strength at quite low twist factors, thus allowing air to pass freely through the interfibre spaces (45). When immersed in water, the fibres expand rapidly and close off the minute spaces in the suit through which perspiration vents. It is aided by the pumping action, or constant positive and negative pressure created inside the suit by normal movement. It is durable, comfortable to wear and reasonably resistant to fuel, oils, greases, and sweat. However, its ability to allow the transmission of water vapour or "breathe", the term that is often used, is limited; it is not unusual to measure one litre of sweat in the suits of Tracker pilots after completion of six-hour fishery patrols (off the coast of Nova Scotia) in the spring and fall. Nevertheless, it has served us well and the L28 material originally chosen has stood the test of time. The new polytetrafluoroethylene film (PTFE) developed by Gore-Tex has been bonded to various materials and manufactured into immersion suits. It is waterproof and it is claimed to be better at resisting oils, greases, etc., than ventile fabric; however, the author has not seen documentation to support this to date. Through its 9 billion pores per square inch, it does allow water vapour to pass and may well be very good for allowing perspiration to pass through light rainwear; however, it is not nearly as air permeable as ventile fabric when incorporated into an immersion suit, the advantage of being windproof may be lost by the disadvantage of not allowing any exchange of air through suit pumping action. A recent ascent by the author to 18,000 ft (½ atmosphere/5486 m) in a Gore-Tex suit confirms that it does not vent well when ascending to altitude and conversely on descent tends to create an uncomfortable negative pressure under the suit until artificially vented. Until Gore-Tex is shown to be superior to L28, the ventile material will continue to be used by most western world air forces.

To provide the required insulation, some manufacturers produce separate liners. These are one-piece suits with zip-up entry in the front; the fabric is designed to trap as

much air as possible into the pile. Once wet, they rapidly loose their insulating properties. They are often nicknamed in the offshore oil industry as "wooly bear liners". Preliminary claims concerning the new Olefin material made by 3M under the trade name of "Thinsulate" (which is supposed to retain some of its insulation when wet), appear to be supported (36). It may be as suggested by Allan that these good features are due to the fact that it does not retain water under normal conditions when wet. This material may indeed be the best for suit liners particularly when the water integrity of the suits is questionable.

NECK SEALS, WRIST SEALS AND ZIPPERS

To make a waterproof seal around the neck is extremely difficult because there is a wide variation in shape and size of the larynx or "Adam's apple" in the male. The only waterproof neck seal in existence is a continuous rubber sleeve type. It can be made in a range of sizes to fit the whole population, but there are disadvantages as follows:

- It is uncomfortable for a large proportion of the wearers and, if fitted too tightly, may restrict venous return;
- Some people pull out the turtleneck of their undershirts to absorb sweat and prevent chafing which in a survival situation acts as a perfect wick and allows water into the suit;
- To get an effective seal, the rubber sleeve should be matched to neck size before being incorporated into the suit, which requires some individual tailoring and, therefore, increases cost;
- The mixture of rubber, stubble of the beard and sweat produces a frank dermatitis in some individuals;
- Rubber deteriorates with time, heat, and ultraviolet light and so there is a significant maintenance cost.

In view of the above difficulties/problems, many types of split neck seals have been devised, none of which is truly waterproof in the abandonment situation. The split seal that is incorporated into the balaclava foam rubber hood shows promise. This has a side opening between the corner of the mouth and the ear, but the latest suit matched specifically to one of our subjects as recently as October 1984, leaked badly when tested in the helicopter underwater escape trainer (HUET) kindly loaned by Survival Systems of Dartmouth. Unfortunately, the hydrostatic effect of water immersion tends to push a large bubble of air into the shoulders and around the neck of the suit. This forces the hood off the face unless it is very tightly fitted. The air valves in the suit were not fitted in the correct position to relieve this pressure.

The majority of split neck seals are uncomfortable, and the end of the zipper tends to catch under the chin or around the mouth area. Some seals are so badly sized that wearers are unsure whether to wear the edge formed by the seal beneath or on the chin. During an escape sequence in the HUET, we have seen one incident where the trapped air in the suit caused the split neck seal to rise up and cut the escapee on the upper lip, clearly not acceptable in a survival situation!

The great advantage of the split neck seal design is that the operator can wear his suit half-unzipped for the flight, or for a portion of the time before he/she abandons the rig, ship or helicopter. This makes the suit more comfortable and allows the suit to breathe freely. However, what is not widely known is that in aircraft water accidents, a recent Canadian Forces study showed that aircrew and passengers received less than one minute warning in 92 percent of cases (13).

Anton recently reviewed seven survivable helicopter accidents in the North Sea and found that in two out of seven cases, the crew and passengers experienced less than one minute warning and in three cases less than five minutes (9). One minute is certainly not enough time to zip up any of the existing suits/balaclava type hoods and tuck in all the complicated lapels. It can be done by trained personnel in the swimming pool, but very few students achieve it in the HUET. It is considered totally impractical during the hectic and probably panic-stricken moments before crashing into the sea.

The best wrist seal is the single rubber sleeve as for the best neck seal. The problems are similar – discomfort, restriction of venous return from the hands, the desire to pull the undershirt sleeve out to absorb sweat and increase comfort, the high cost of individual tailoring to match suit to wrist size, and rubber deterioration. Additionally, the wrist seals tend to split because users often force their hands through the seals rather than taking the time to use powder to ease donning the suit. To give more flexibility, many types of inner and outer zips and neoprene seals often incorporating gloves have been developed into the wrist seal.

Apart from the suit system which incorporates integral gloves that cannot be removed, there are none as waterproof and convenient to use as the simple rubber seal. The integral glove gives good hand protection but seriously degrades manual dexterity. The Royal Air Force provides their aircrew with a glove that gives good manual dexterity, integrity, and short-term warmth. This allows the survivor to carry out the essential parts of the survival routine before

his/her hands get cold. Once the gloves are totally saturated, they lose all insulation, but by that time, the survivor should be in a dinghy with access to heavy dry winter mitts in the survival kit.

Technically, the new waterproof zips work well, nevertheless they need to be treated with reasonable care and still need lubrication and a considerable amount of maintenance to keep them working smoothly and waterproof. The site of the zipper is not standardized. Basically, there are front entry, back entry, and split neck entry suits. Some have zip entries for urination ports. As discussed above, two specific problems with the split neck seal are that the zip is extremely uncomfortable where it interferes with the Adam's apple, and it is difficult to zip up tight in the ditching situation.

HYPOTHERMIA PROTECTION

Practically speaking, it is not possible to put more than about 3.5 CLO of thermal insulation on a human in air and expect him/her to function. One CLO is defined as the clothing insulation of a thermally comfortable man sitting at rest in an environment of 21 degrees centigrade, 50 percent relative humidity and 0.11 m/s air speed. The modern approach to survival is to specify the required level of immersed clothing requirement rather than specify the maximum allowable fall in body temperature (4, 6). Immersed insulation CLO values are reduced by removal of boundary air layers and by the hydrostatic squeeze of the water. This was reported to be 56 percent by Hall and Polte (22), 80 percent by Goldman (21), and 71 percent by Allen, Higenbottam and Redman (3). For survival in the icy waters of the East Coast of Canada, at least a minimum of 2.3 CLO in air is necessary (3). When the survivor is immersed in water, this insulation is reduced to 0.75 to 0.80 CLO by the simple hydrostatic squeeze of the water. There are suits available with and without lining that will provide this insulation. Some of the foam rubber suits provide as much as 1.1 immersed CLO (6).

To get this immersed CLO value, the wearer must enclose himself in the near equivalent of full arctic clothing for helicopter flying as crew or passenger, but this only contributes to his discomfort en route and, therefore, increases the unpopularity of the suit.

FLOTATION CHARACTERISTICS

Due to the volume of trapped air required to provide the immersed CLO value on insulation, most suits provide a poor flotation angle. The air is evenly distributed over the body and tends to support the wearer in a horizontal position on the water surface, either in the face up or face down position. In addition, between 45 and 55 pounds of buoyancy is required in a well-designed life preserver to provide self-righting characteristics. The habit developed by some manufacturers to provide longitudinal elasticated zip-up panels in the legs to tighten the fabric when the suit is donned only traps additional air, complicates the suit and makes it more expensive. There is no substitute for increasing the number of sizes of suits. A good suit with life preserver should ensure that the survivor is facing the waves and that the head is inclined back at about 30 degrees so that the incoming wave can be seen. Unfortunately, many life preservers are not designed in conjunction with the immersion suit and are often incompatible (26).

Recently, it has been considered that many deaths originally attributed to hypothermia were actually caused by drowning. The survivor would become colder, weaker, and demoralized by the waves crashing over the face and, ultimately unable to fight the next series of waves, would inhale water and simply drown (18, 19, 20). Some life preservers actively funnel water on to the face! Clearly, there should be some form of protection to prevent inhalation of spray from waves crashing over the survivor's face. This can be achieved by a transparent protective face shield and/or a portion of the inflated bladder of the life preserver. There is only one known suit, available from a U.K. manufacturer, that comes close to achieving these features. Another U.K. company is known to offer face shields as an "add on" modification to existing life preservers.

Manufacturing companies add on an array of survival aids scattered around the suit, causing bulk that encourages snagging when escaping, traps air in inappropriate positions, and even hinders escape by the addition of too much inherent buoyancy. Suits should present a slimlined, smooth external surface that facilitates escape and ease of entry into a life raft. There are very few suits designed with such features.

The requirements for escape from a downed, inverted helicopter present a paradox. On the one hand, there is the requirement to have a considerable amount of trapped air in the suit system to provide the necessary immersed CLO insulation, yet, on the other hand, too much will seriously hinder the survivor from escaping from an inverted flooded helicopter. Panic-stricken and semi-drowning, the disoriented person thrashes about helplessly against the floor of the helicopter trying to find an escape route.

Inherent buoyancy in current suits varies between 4 and 32 pounds. The Norwegian regulations require there to be less than 5 litres of air in the suit after 10 seconds immersion (29). Brooks and Provencher (14) suggested the maximum allowable inherent buoyancy for a suit should be 20 pounds. This study has just been re-examined in the dynamic situation of the HUET. Preliminary recommendations to the Canadian General Standards Board by Bohemier, Brooks and Potter are that a weight with suit, life preserver and liners measured at 15 seconds after total immersion is a more practical and representative value to measure. Work is currently underway to validate and establish a maximum figure for this value.

Escape from a submerged, inverted helicopter is always a difficult task. It is particularly difficult if the survivor is very buoyant with the tendency to float towards the inverted deck. This is one of the reasons why no life preservers are provided for helicopter use with automatic water-activated buoyancy chambers. Nevertheless, the inherent buoyancy in each suit, liner, and air trapped between each layer from the skin to the outside layer can be extremely high. Valves may be provided in the chest and legs to allow rapid release of trapped air; however, on some suits the valves are not fitted in the optimum position, are covered by an inside suit liner preventing rapid air exit, or indeed set with such a high blow-off pressure that they do not work. They need maintenance and often leak, thereby compromising the integrity of the suit.

The life preserver should be designed in conjunction with the immersion suit, to ensure that the correct buoyancy and flotation angle will be provided. Many manufacturers are indeed now doing this. There is still some resistance by North American customers to insist on self righting. An injured person on his face in a rough sea is unlikely to survive and an unconscious person will certainly perish. Ice build up on the body can also alter position from face up to face down (26). Self-righting characteristics should be insisted upon for any standard established by the Canadian General Standards Board.

OTHER CONSIDERATIONS

Customers can pay a wide range of prices for immersion suits. The old adage that you only get what you pay for is not strictly true here. While suits range between $200 and $1,200, the best one for preventing hypothermia and providing the least hindrance to escape and the one used by professional trainers costs $425. In order to be able to escape from a burning helicopter, ship or rig, suits should be made of fire retardant material (29). More manufacturers are offering this feature now, but the best materials, NOMEX III and Polybenzimidazole (PBI) are expensive (47). On average, this increases the cost of individual suits by a factor of three.

The level of quality control during manufacturing differs from company to company but, in general, is not as good as should be expected. Within the last two years, the author has tested brand new suits which have leaked during the first immersion at the junction between the footlets and the leg, at the zippers, and at the stitching around the buttocks. Quality control however, appears to be improving.

Unacceptably high leak rates were found in RAF in-service immersion suits during two recent studies by Anton and by Allan et al (7, 10). Maintenance is essential to keep a suit in good condition. It should be regularly tested for leaks (8) and particular attention must be paid to neck seals, wrist seals, zippers, footlets, and the overall general condition of the suit.

DISCUSSION

Life-support and survival equipment has always been viewed by industry as the non-profit-making segment of their business. Perhaps understandably, there has been a great temptation to provide the cheapest type of suits. Manufacturers attempting to provide such a suit have failed to satisfy performance/functional requirements. One size just does not fit all and skimping on the quality of neck seals, wrist seals, and zippers does not work. Cheaper varieties of rubber degrade quickly; the author has seen wrist and neck seals tear after a new suit has been donned and doffed as little as three times.

Ideally, to get a good fit, each suit should be individually tailored. Knowing this to be basically impractical and not cost effective, manufacturers should be encouraged to increase the number of sizes. Nine sizes should fit most males and some females. An additional three smaller sizes should fit most of the smaller females. They should also be aware of the differences between individuals in their attitudes to clothing, the excellent review by Flugel (17), and the discussion on the subject that occurred at the Third Shirley International Seminar (15).

The opinions of users of immersion suits vary widely. A suit that is considered (truly or falsely) to be uncomfortable, even if it is the best suit in existence, may not be bought by potential customers and, if it is bought, may not be used by employees. We

must pay attention to user complaints that the suits are uncomfortable. The prime aim of any designer is that the suits should not leak and should be comfortable. The author views with dismay some of the manufacturers' products designed to achieve this requirement.

It would be inappropriate to legislate towards or away from specific design concepts, such as type of seals to be used. The end result would be that the operator would simply not wear the suits and it would be difficult if not impossible to implement the regulations; it might also exclude helpful innovations.

With the variation in different shapes and diameters of the human neck, it is impossible to mass produce an immersion suit with a split neck seal that is truly waterproof. However, with the appropriate funding, it should be possible to produce a better ventile fabric which includes fire retardant properties and it is believed that there is such a product now in existence in Finland (28).

There is no suit that fulfills every criterion, but there is one suit used in cold water which gives excellent hypothermia protection. Combined with two inner wooly bear liners, it provides at least 0.75 immersed CLO causing minimal restriction to mobility. It is waterproof and, of equal importance, the fabric is extremely durable and maintenance costs are small. The disadvantages are that the suit is not made of ventile fabric, is not fire retardant, and incorporates a continuous non-split rubber neck seal. Paradoxically, this suit which is the best available for the offshore industry has had poor user acceptance. Not unreasonably, operators do not like to wear it because it can be uncomfortable when worn for a long time, particularly when waiting in air terminals, in the helicopter with heaters on and when any work is required. Sweat cannot evaporate and so the liner becomes sodden and extremely uncomfortable.

Technically the immersion suit has reached the peak of its development in the form we know it today; there is little room for improvement. Pictures of immersion suit trials taken in British Columbia in 1943 could well have been taken in Lake Ontario in 1984; the sizes and shapes of suits, wrist seals, neck seals and types of closures are identical to those of today. Entirely new concepts of protection using modern technology should be encouraged. But the need to use an immersion suit (and many other types of safety equipment) is really dictated by the consequence of not using it should an incident occur rather than the probability that an incident will occur. Obviously, with this view, compromises in comfort and mobility in normal operations are necessary, and this must be recognized when selecting and using a suit.

What is the incidence of immersion compared to user time of the suits? Operators commonly ask why they should put up with many hours of discomfort in a suit which may never be required.

CONCLUSIONS

1. With the exception of drowning, hypothermia is the greatest threat to life in North Atlantic waters. With current technology, a dry suit is of cardinal importance for survival.

2. Any suit which may be perceived (correctly or not) to be uncomfortable will get poor user acceptance.

3. If this occurs, standards or regulations issued concerning the wearing of the suit may be difficult and even impossible to implement.

4. The prime objective of any suit designer and manufacturer must be to produce a comfortable suit.

5. Currently there is no suit in existence that fulfills all criteria for an immersion suit.

6. There is a suit in production that gives excellent hypothermia protection, has a slim, smart appearance, provides the minimum hindrance to escape and is highly praised by operators working in cold water.

7. Helicopters' and ships' crew generally consider the above suit to be uncomfortable and therefore unacceptable because the neck seal is not split, the fabric is not ventile and the material is not fire-retardant.

8. It is considered technically impossible to make a truly waterproof immersion suit using a split neck seal that can be mass produced to fit all sizes of operators.

9. Legislation to insist on non-split neck seals will produce low user acceptance and be impossible to enforce.

10. Good regular maintenance is essential to keep suits serviceable and water-tight.

11. The immersion suit in its current form has reached the peak of its development and is considered unable to fulfill all of the requirements.

12. Canadian industry along with federal and provincial agencies should be invited to consider new concepts in the design of a survival suit for use in cold, hostile environments.

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ITEM D-3

HELICOPTER PERFORMANCE AND EQUIPMENT

TABLE D-3
Helicopter Performance, Equipment and Limitations Relating to a Typical Rescue Mission

CRITERIA	SARCUP (1)	SEA KING	S-61N	SUPER PUMA
Performance				
1. En Route Speed	115 kts	115 kts	115 kts	135 kts
2. Endurance to Zero Fuel (2)	5 hrs 33 min Summerside 5 hrs 12 min Gander	4 hrs 15 min	5 hrs	5 hrs 30 min
3. Zero Wind Radius of action to Zero Fuel (2)	309 nmi Summerside 289 nmi Gander	234 nmi	277 nmi	360 nmi
4. Maximum Load (Passengers – PAX and Litters – LIT)	18 PAX or 6 LIT plus 10 PAX	12 PAX	18 PAX	17 PAX (C Model) 19 PAX (L Model)
Wind Limits				
5. Rotor Spread (3)				
• Tail Rotor	—	40 kts	—	—
• Main Rotor	—	45 kts	—	—
6. Rotor Start/Stop	52 kts steady decreasing to 30 kts mean with 15 kts gust spread (4)	60 kts within 45° of the nose, decreasing at other angles	45 kts	55 kts on the nose decreasing at other angles
Weather Limits (5)				
7. Takeoff – Land Base	200'/¼ m	200'/¼ m	100/¼ m (6)	100'/¼ m (6)
8. Takeoff – Ship	—	200'/½ m	—	—
9. Takeoff – Rig	200'/½ m	200'/½ m	150'/½ m	150'/½ m
10. Icing	Helicopters are not permitted to fly into known icing. If icing is encountered, they are required to leave the icing zone.			
11. Landing – Land Base	200'/¼ m	200'/¼ m	200'/¼ m	200'/¼ m
12. Landing – Ship	—	200'/½ m	—	—
13. Landing – Rig	200'/½ m	200'/½ m	150'/½ m	150'/½ m
Rig Operating Limits (Emergency)				
14. Heave at Helideck			45'	30'
15. Pitch – Engine Running			10°	12°
16. Pitch – Shut Down	At Aircraft Commander's Discretion.	At Aircraft Commander's Discretion.	10°	10°
17. Roll – Engine Running	No Limits Published.	No Limits Published	10°	8°
18. Roll – Shut Down			10°	5°
19. List			10°	12°

continued

TABLE D-3 (continued)
Helicopter Performance, Equipment and Limitations Relating to a Typical Rescue Mission

CRITERIA	SARCUP	SEA KING	S-61N	SUPER PUMA
Communications Equipment				
20. High Frequency (HF)	■	■	■	■
21. Very High Frequency AM (VHF-AM)	■	■ (7)	■	■
22. Very High Frequency FM (VHF-FM)	■	■ (7)	■	■
23. Ultra High Frequency (UHF)	■	■		
Navigation & Specialist Equipment				
24. Omega	■			■
25. VLF, ONTRAC 3			■ (8)	■
26. LORAN			■ (8)	
27. Radio Compass	■	■	■	■
28. VHF Omnirange (VOR)	■		■	■
29. TACAN	■	■		
30. Distance Measuring Equipment (DME)	■	■	■	■
31. Transponder	■	■	■	■
32. Instrument Landing System (ILS)	■	■	■	■
33. Radar Altimeter	■	■	■	■
34. Airborne Radar	■	■	■	■
35. Airborne Radar Beacon Mode	■		■	■
36. Direction Finder	■	■	■	■
37. Automatic Flight Control System (AFCS)		■	■	■
38. Doppler Radar		■		■
39. Sling Hook/EMPRA Capability	■	■	■	■
40. Hoist	■	■	■ (9)	■ (9)

NOTES:

(1) The version of the SARCUP helicopter based at Gander is the upgraded CH-113 Labrador which was procured in the early 1960s, in SAR configuration with large external fuel tanks. The version based at Summerside is the upgraded CH-113A Voyageur for which external tanks were procured during the "speedline" portion of SARCUP and were available only with an increased capacity.

(2) Endurance and radius of action for all four helicopters are calculated on the same basis for comparison purposes. They assume 10 minutes for start-up and taxi, but do not allow for final reserves which would vary, depending upon flight planning requirements, determined by weather, location, availability of alternates, etc.

(3) Limits apply to operation from a vessel at sea.

(4) Rotor start/stop wind limitation does not apply to Summerside, PEI, where helicopters may be started and shut down in an alert hangar.

(5) Weather limits are CEILING (measured in feet)/VISIBILITY (measured in miles). Land base takeoff and landing limits are based on airfield precision approach limits published by DOT and DND. Although these may vary between airfields, depending on the runway in use, the serviceability of approach aids and a number of other factors, these limits nevertheless provide a reasonable basis for comparison.

(6) Reduced takeoff minima of 100'/¼ m are granted by DOT on application by an operator. This approval is provided following a review of company operations, pilots, aircraft and onboard equipment, in addition to approach aids available at the airport.

(7) Fitted with VHF-AM or VHF-FM

(8) Fitted with VLF or LORAN

(9) May be fitted; limited duty cycle

Source: *An Assessment of Search and Rescue for East Coast Offshore Exploration Drilling Operations.* Vice-Admiral J.A. Fulton (Ret'd), Lt. Colonel J.E. Dardier (Ret'd), Major H.F. Pullen, (Ret'd). A study prepared for the Royal Commission, November 1984.

GLOSSARY

GLOSSARY

ABS American Bureau of Shipping

ADS one-atmosphere diving system

AES Atmospheric Environment Service

abandonment suit A generic term used to describe protective clothing which offers varying degrees of insulation from cold air and water.

auto-hover coupler system In conjunction with an automatic flight-control system, this system uses a doppler radar and allows a helicopter to maintain a hover position without assistance from the pilot.

BAST Best Available and Safest Technology

BOST *See* Basic Offshore Survival Training

BOT *See* Basic Offshore Training

Basic Offshore Survival Training (BOST) A 10-day basic safety training course offered by the Institute of Fisheries and Marine Technology (formerly the College of Fisheries, Navigation, Marine Engineering and Electronics) in St. John's, Newfoundland and developed for the Government of Newfoundland to meet its requirements for the basic safety training to be acquired by all offshore workers.

Basic Offshore Training (BOT) A 5-day basic safety training course developed by industry in response to a 1983 COGLA requirement that all offshore workers receive basic safety training.

bergy bit A small iceberg or iceberg fragment categorized as having a height of 1 to 5 metres, a length of 6 to 20 metres, and a weight of 200 to 700 tonnes. A bergy bit is larger than a growler.

Billy Pugh basket A rescue net, weighing approximately 9 kilograms, which may be attached to a helicopter hoist system for rescue purposes. When the net is trailing in the water, its opening is stabilized by an attached sea anchor which also serves to diminish the effects of waves on the net. The net is provided with a hinged stand-up device which automatically forms a rigid cage when the net is fully extended.

CAODC Canadian Association of Oilwell Drilling Contractors

CASP Canadian Atlantic Storms Project

COGLA Canada Oil and Gas Lands Administration

COVOA Canadian Offshore Vessel Operators Association

CPA Canadian Petroleum Association

CPA OOD Canadian Petroleum Association Offshore Operators Division

classification society An independent organization whose purpose is to supervise the construction, upkeep and alteration of vessels according to the society's rules for classing each particular type of vessel. Athough not compulsory by law, constructing a vessel according to the rules of a society makes it much easier for the owner or charterer to secure satisfactory insurance rates.

Coastal State A state exerting regulatory control over vessels operating within its jurisdictional limits.

critical system A system which may affect the structural integrity, stability, seaworthiness or safety of a MODU.

damage stability The reserve stability of a vessel in a prescribed damaged condition; one of the criteria used in the classification process.

davit A small crane located at the edge of a deck, used for lowering lifeboats and davit-launched life rafts.

dedicated SAR resources Search and rescue aircraft, vessels and equipment, the primary function of which is to provide search and rescue services to persons involved in air and marine distress incidents.

downflooding The unintentional entry of water into a compartment. The "first point of downflooding" is the lowest opening through which water can enter the internal structure of a vessel, while the "angle of downflooding" specifies the inclination at which downflooding first occurs.

draft The depth of the keel from the surface of the water. The draft of a drilling rig is controlled by taking on or discharging ballast water.

drilling program A program for the drilling of one or more wells within a specified area and time using one or more drilling units and including all ancillary operations and activities. Approval for a drilling program is granted to an operator upon provision of detailed information on the exploration program including extensive documentation on the purpose, location, timing, nature, and logistics of the program. Geological and environmental data, information on rigs to be used, and a detailed contingency plan for emergencies must also be provided to the regulatory authority issuing approval.

dynamic positioning A method of maintaining the position of a vessel or floating MODU with respect to a point on the seabed by activating propulsion units in response to signals received from position-error detection sensors. Dynamic positioning may be used in addition to a mooring system, or independently; when used as the sole method of station-keeping, such a system allows a rig to manoeuvre rapidly to avoid approaching ice.

ELT emergency locator transmitter

EMPRA *See* emergency multiple person rescue apparatus

EPIRB emergency position indicating radio beacon

EPOA Eastcoast Petroleum Operators Association

emergency multiple person rescue apparatus (EMPRA) A collapsible, open-top ring net with a rigid base, designed to be slung from beneath a helicopter cargo hook or sling, or from a ship's crane or boom mast for man-overboard situations and rescue from lifeboats. The model used offshore can hold up to 20 persons and weighs just over 230 kilograms.

FRC *See* fast rescue craft

falls The wireropes with which lifeboats are attached to davits.

fast rescue craft (FRC) A rigid inflatable boat about 4.5 to 9 metres in length carried on board vessels or rigs for man-overboard rescue. Launching and recovery are achieved by crane.

Flag State The country in which a vessel is registered.

GM *See* metacentric height

growler A small piece of floating sea ice, categorized as having a height of up to 1 metre, a length up to 6 metres, and a weight up to 200 tonnes. Smaller than a bergy bit.

HUET *See* helicopter underwater escape training

heave The total vertical movement of a vessel relative to the seabed. Heave is of great significance in the operation of floating drilling platforms, since the rig is connected to the seabed. Heave or motion compensators will protect the drilling equipment within certain specified limits.

heel The inclination of a vessel to port or starboard.

helicopter underwater escape training (HUET) Gives personnel who travel by helicopter an understanding of helicopter abandonment procedures, particularly the actions required to abandon a ditched and/or capsized helicopter. Training in the latter aspect is achieved through use of a simulator in an indoor pool.

hindcasting A procedure for deducing from historical weather data for a particular area the corresponding sea states of that area. Wind speed, direction, duration, and fetch are derived from records of the atmospheric pressure field and are used to calculate the height, the period and the direction of the waves which would have been produced.

hyperbaric chamber A compartment which can be sealed and pressurized to reproduce the pressures encountered by divers at various water depths. Used as a compression/decompression chamber for diving work and as a training and research tool.

hyperbaric medicine A branch of medicine dealing with the physiological effects of compression and decompression.

hypothermia The condition of abnormally low body core temperature produced by exposure to cold air or water. Normal body temperature is 37°C; incapacitation generally results from drops in this core temperature to 35°C, semi-consciousness occurs at around 30°C and death at between 28°C and 24°C.

ICSAR Interdepartmental Committee on Search and Rescue

IMO International Maritime Organization

inclining test An experiment carried out under the direction of a classification society on new vessels or MODUs to determine the lightship weight and the position of the centre of gravity for comparison with previously calculated values. The test is carried out by moving known weights across the deck under controlled conditions and noting the resulting change in the angle of heel.

Load Line Convention The *International Convention on Load Lines* was adopted by the Inter-governmental Maritime Consultative Organization (now the International Maritime Organization) in 1966 to establish an international standard for the maximum permissable loading of ships.

MED *See* Marine Emergency Duties

METOC Canadian Forces Meteorological and Oceanographic Centre

MODU mobile offshore drilling unit

Marine Emergency Duties (MED) I, II, III Certificates issued by the Canada Ministry of Transport for training of seamen to various levels of competence in dealing with marine emergencies. Training is provided in the use of lifesaving appliances, firefighting, rescue and survival, and first aid.

mesoscale phenomena Atmospheric disturbances which are severe enough to affect activities in the relatively small area where one occurs, but which are too confined geographically to be detected readily by the established network of observing stations.

metacentric height The vertical distance between the centre of gravity (G) and the transverse or longitudinal metacentre (M_T or M_L), abbreviated GM_T or GM_L. A measure of stability: a vessel is stable when its centre of gravity is below its metacentre.

nautical mile The standard unit of measure for marine navigation; one nautical mile equals 6,000 feet.

ODECO Ocean Drilling and Exploration Company

OFINTAC Offshore Installations Technical Advisory Committee

OPEC Organization of Petroleum Exporting Countries

on-scene commander A position assigned when a search and rescue mission takes place where communications may be a problem and on-site co-ordination is essential.

PITS Petroleum Industry Training Service

PLB personal location beacon

PROD (preferred orientation and displacement) A flexible boom developed by Watercraft as a method of maintaining a TEMPSC away from the drilling rig's structure during lowering and after release. The boom, connected to the bow of the TEMPSC by a tag line, ensures that the lifeboat faces bow-outward; the tag line is released when the boat accelerates away from the rig.

personnel basket A basket suspended from the crane of a rig and used for the transfer of personnel to and from supply vessels.

punch-through The failure of the seabed foundation supporting the leg of a jack-up drilling rig.

ROV remotely operated vehicle

real-time observational data Observations of environmental conditions which are forwarded immediately for use in the preparation of forecasts, as opposed to being stored for subsequent analysis or distribution.

remote sensing The detection of an object or phenomenon by an information-gathering device or sensor (such as radar or other imaging devices) without direct contact.

rime icing Occurs when precipitation freezes on impact and builds up on a surface in a bumpy layer. It may seriously distort airfoil shape, diminish lift, and prevent aircraft from flying safely.

SAR search and rescue

SARCUP Search and Rescue Capability Update Program. Undertaken by the Government of Canada to modernize its fleet of Labrador/Voyageur helicopters.

SARTECH search and rescue technician

SEA kit standby emergency assistance kit

SOLAS (Safety of Life at Sea) The *SOLAS Convention* deals with the design of a vessel as it affects the safety of life. It covers structure and machinery, communications equipment, and lifesaving appliances.

scatterometer A satellite-borne instrument capable of measuring wind speed and direction over large areas of sea.

TEMPSC Totally enclosed motor propelled survival craft.

telemedicine The use of voice, and sometimes video, communications to allow medical professionals to provide assistance in diagnosis and treatment of a patient who is at a remote location.

trim The inclination of a vessel to the bow or stern.

UKOOA United Kingdom Offshore Operators Association

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